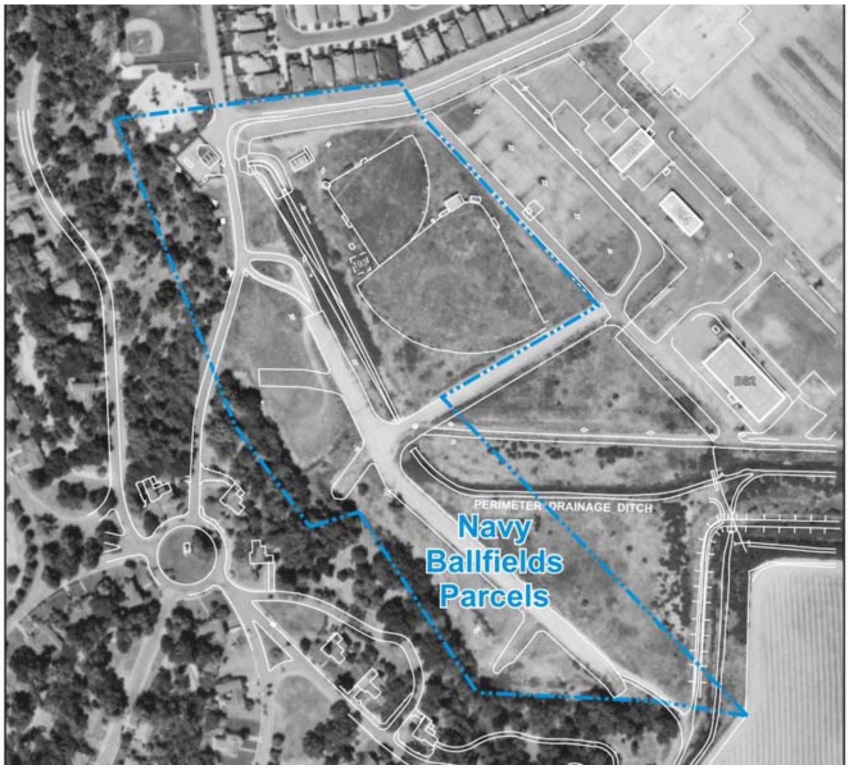
Final
Preliminary Assessment/Site Inspection for Ballfields Parcels at Department of Defense Housing Facility Novato, California



Prepared for:

Base Realignment and Closure
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, CA 92108

Prepared under:

Naval Facilities
Engineering Service Center
1100 23rd Avenue
Port Hueneme, CA 93043

CONTRACT NUMBER: N47408-01-D-8207
TASK ORDER: 0063

by

Battelle

Environmental Restoration Department
505 King Avenue
Columbus, OH 43201

April 14, 2006

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Travis Williamson, P.E. ______________________ Date 4/11/06
Project Manager, Battelle

REGISTERED PROFESSIONAL ENGINEER
TRAVIS WILLIAMSON
C 68119
EXP. 06/30/07
CIVIL
STATE OF CALIFORNIA

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ACRONYMS AND ABBREVIATIONS

AE	assessment endpoints
AOPC	area of potential concern
ATSDR	Agency for Toxic Substances and Disease Registry
BAF	bioaccumulation factor
bgs	below ground surface
BRAC	Base Realignment and Closure
BTAG	Biological Technical Assistance Group
BW	body weight
Cal-EPA	California Environmental Protection Agency
CAM	California Administrative Method
CAS	Columbia Analytical Services, Inc.
CCC	California Coastal Conservancy
CLP	contract laboratory program
COPC	chemical of potential concern
COPEC	contaminant of potential ecological concern
CSM	conceptual site model
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DoD	Department of Defense
DoDHF	Department of Defense Housing Facility
DTSC	Department of Toxic Substances Control
GPS	global positioning system
HAAF	Hamilton Army Airfield
HI	hazard index
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
HQ	hazard quotient
HT	holding time
HWRP	Hamilton Wetlands Restoration Project
LDC	Laboratory Data Consultants
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
LOAEL	lowest observed adverse effects level
MDL	method detection limit
MRL	method reporting limit
NA	not available
NFESC	Naval Facilities Engineering Service Center
ng/g	nanogram per gram
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration

NOAEL	no observed adverse effects level
NS&T	National Status and Trends
ORNL	Oak Ridge National Laboratory
PA	preliminary assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDD	perimeter drainage ditch
PEA	Preliminary Endangerment Assessment
PHG	Public Health Goal
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
ROC	receptor of concern
ROD/RAP	Record of Decision/ Remedial Action Plan
RSP	Revetment Spoils Pile
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SI	site inspection
SLERA	Scoping-Level Ecological Risk Assessment
SPN	Spoils Pile N
SSL	Soil Screening Level
SUF	site use factor
SVOC	semivolatile organic compound
TDS	total dissolved solids
TEF	toxic equivalent factor
TNT	trinitrotoluene
TPH	total petroleum hydrocarbon
TPH-D	total petroleum hydrocarbons quantified as diesel range
TPH-G	total petroleum hydrocarbons quantified as gasoline range
TPH-RRO	total petroleum hydrocarbons quantified as residual range organics
TRV	toxicity reference value
UCL	Upper Confidence Limit
USACE	U.S. Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound

EXECUTIVE SUMMARY

Background

A Preliminary Assessment/Site Inspection (PA/SI) for the Ballfields Parcels located at the Department of Defense Housing Facility (DoDHF), Novato, California, was conducted by the Navy in order to determine whether this property could be readily transferred to the California Coastal Conservancy (CCC) for seasonal wetlands reuse in accordance with the *Hamilton Army Airfield Final Reuse Plan* (Hamilton Local Reuse Authority, 1996). In order to determine suitability for transfer, the property was evaluated through a PA/SI to determine if chemicals in soil and groundwater pose a significant threat to human health or the environment.

The subject site of this report includes Parcels 108A, 110, 112, 114, 115A, and 117 ("Ballfields Parcels") at DoDHF Novato, located approximately 20 miles north of San Francisco in Marin County, CA. In 1932, the U.S. Army Air Corps constructed Hamilton Army Airfield (HAAF) on reclaimed tidal wetland, which had been used as ranch and farm land since the Mexican Land Grant. Military operations began in the area in December 1932. In 1947, HAAF was transferred to the Air Force and renamed Hamilton Air Force Base. The Air Force owned and operated the Base until 1974, at which time it was deactivated. In 1975, residential portions of the Base were transferred to the Navy, and other portions were transferred to the Coast Guard and Army. The Navy used the Ballfields property as a baseball field and open space starting in 1974, until DoDHF Novato (administered by the Navy) was scheduled for closure under the Base Realignment and Closure (BRAC) program in 1994. Prior to the Navy's use of the Ballfields Parcels, the Air Force performed various military functions such as parking aircrafts at revetments for staging and refueling.

A historical documents review of the Ballfields Parcels was conducted and reported in the Background Summary report (Battelle, 2004). Based on this review, a few specific geographical areas within the Ballfields Parcels and the presence of area-wide dichlorodiphenyltrichloroethane (DDT) associated with the former Army BRAC property were identified as potential concerns for further investigation. The geographical areas, designated as areas of potential concern (AOPCs) in this report, were identified as five former airplane revetments, Spoils Pile N (SPN) and Revetment Spoils Pile (RSP) originating from the Perimeter Drainage Ditch (PDD), and two former ordnance magazine buildings (Buildings 191 and 193). As a result of the historical records review, certain hazardous substances in addition to the DDT also were identified as being present or potentially present at some of the AOPCs based on historical activities that occurred at the AOPC. Therefore, as part of the PA/SI, soil and groundwater samples were collected in April 2005 from these AOPCs to confirm or determine the presence of DDT and other hazardous substances. Based on a request from the Department of Fish and Game, the Navy also included the PDD as an AOPC, and collected soil samples from along the top of the banks of the PDD to analyze for DDT and metals.

Soil and groundwater samples were collected in accordance with the site-specific sampling and analysis work plan (Battelle, 2005). Chemical analyses varied by AOPC, but included total petroleum hydrocarbons as gasoline, diesel, and residual range organics (TPH-G, TPH-D, TPH-RRO, respectively); semivolatile organic compounds (SVOCs) (including polycyclic aromatic hydrocarbons [PAHs]); volatile organic compounds (VOCs); explosives, polychlorinated biphenyls (PCBs), and 17 California Administrative Method (CAM) metals. Analytical results varied by AOPC. Generally, low levels of VOCs were sporadically detected across the site, whereas the SVOCs were detected more frequently at low levels, especially in the revetment areas. Metals were commonly detected across the Ballfields Parcels, often at concentrations consistent with background conditions. The presence of DDT was detected in the spoils piles and along the PDD. Only two explosive compounds were tentatively identified in soil, but at very low levels. Soil samples for PCB analysis were not detected above human or ecological conservative screening criteria and therefore did not warrant further sampling at the Ballfields Parcels.

In order to determine if chemicals present in soil and groundwater pose a significant threat to human health or the environment, both human health screening-level and ecological risk evaluations were conducted. Results of the screening evaluations are summarized in Table ES-1 for risk to human health and ES-2 for ecological risk, and are described below.

Human Health Screening Evaluation

As a conservative measure to assist in making risk-management decisions for the Ballfields Parcels, a hypothetical residential scenario, rather than the actual site recreational visitor scenario, is used to evaluate the risks associated with exposure to chemicals detected in soil and groundwater. Potential risk to human health is evaluated by comparing maximum concentrations detected in soil and groundwater to residential United States Environmental Protection Agency (U.S. EPA) Region 9 Preliminary Remediation Goals (PRGs). In addition, vapor intrusion to indoor air also was evaluated for the hypothetical residential receptor. The screening evaluation was conducted on a site-wide basis, whereby analytical data obtained from each AOPC were combined and evaluated as one dataset. Results of the human health screening-level evaluation, as summarized on Table ES-1, indicate that the estimated total cancer risk and noncancer hazard index (HI) for soil is 5.3×10^{-6} and <1.0, respectively. Inclusion of the vapor intrusion exposure pathway and the use of the conservative hypothetical residential receptor artificially inflates the cancer risk estimates for the Ballfields Parcels. The risk is inflated because exposure to chemicals in soil would not be expected to be as frequent, or be present over such an extended period of time, for a site recreational visitor as compared to the residential receptor. Given the conservative nature of the screening-level risk assessment, which evaluates the Ballfields Parcels under a hypothetical residential scenario rather than the more appropriate site recreational visitor, the estimated total cancer risk and noncancer HI estimated for exposure to chemicals in soil at the Ballfields Parcels indicate there is no significant threat to human health for the applicable site receptor.

Exposure to groundwater is associated with total cancer risk and noncancer HI of 1.3×10^{-2} and 14, respectively (Table ES-1). It is important to note that these estimates of cancer risk and noncancer HI are the result of the hypothetical residential receptor using the groundwater beneath the site as drinking water. Ingestion of metals (arsenic and vanadium) in groundwater is the primary reason for the elevated risk/hazard estimates. Groundwater beneath the Ballfields Parcels is not suitable for use as drinking water because of high total dissolved solids (TDS), very low recharge rates, minimal saturated aquifer thickness, and the lack of an adequate vadose zone for sanitary well seals. In addition, the low yield and high salinity of groundwater present at the Ballfields Parcels precludes its use for any other beneficial purposes, including agriculture, irrigation, and industrial use. As such, even if a residential housing development were to be constructed on the Ballfields Parcels, groundwater beneath the property would not be used for consumption and the residents would be supplied water from the City of Novato which is the current source of drinking water at the site. Therefore, the only potentially viable exposure route of concern for either the hypothetical resident or the more applicable site recreational visitor is inhalation of chemicals that volatilize from groundwater. However, results of the vapor intrusion pathway indicated that the inhalation route of exposure is not associated with unacceptable risk/hazard (i.e., less than 1×10^{-6} for risk and 1.0 for hazard). Thus, because groundwater will not be used for drinking water, regardless of the type of receptor, the estimates of groundwater risks/hazards presented here overestimate the actual risks associated with the site. Therefore, no significant threat to human health associated with chemicals in groundwater exists at the Ballfields Parcels for the hypothetical resident or the more likely recreational site visitor.

Table ES-1. Summary of Human Health Screening Level Evaluation

Human Health Screening Evaluation Results[a]			
Soil		Groundwater	
Cancer Risk	Hazard Index[b]	Cancer Risk	Hazard Index
5×10^{-6}	<1.0	1×10^{-2}[c]	14[c]

(a) Exposure to lead results are not included in the estimates of risk/hazard, but rather directly compared to PRGs. All concentrations detected are less than U.S. EPA Region 9 PRGs.
(b) The hazard index is the summation of hazard quotients derived for each of the chemicals of potential concern.
(c) These risks are overestimated for an actual receptor because groundwater is not currently, nor will it likely be used for drinking water or any other beneficial use in the future due to high TDS, low yield, and the fact that the City of Novato already supplies this area with potable water.

Ecological Risk Evaluation

The potential for adverse effects to upper-trophic level receptors resulting from exposure to contaminants in soil was evaluated. A dose assessment was performed using maximum concentrations of chemicals detected in surface soil to determine potential risks. These doses were used to derive two hazard quotients (HQs) for each contaminant of potential ecological concern (COPEC) at the Ballfields Parcels, an HQ_{low} using a low toxicity reference value (TRV), and an HQ_{high} using a high TRV. Results indicated that all of the HQs_{high} for each of the receptors of concern (ROCs) were well below 1.0, but also indicated that some of the HQs_{low} for various metals, Total DDT, 2,6-DNT, and HMX were above 1.0 for various ROC. Therefore, a second dose assessment was conducted to examine the subset of COPECs that were determined to have HQs_{low} above 1.0 in the first dose assessment. For this additional dose modeling, however, 95% UCL soil concentrations were used, rather than maximum soil concentrations (unless the maximum concentration was lower), in order to take into consideration concentration and spatial variability of the chemicals detected in surface soil at the site. Both dose assessments included two low TRVs for the avian receptors for lead: the Navy/BTAG TRV (U.S. EPA, 2002) and the Eco-SSL TRV (U.S. EPA, 2005) as a means to provide a range of risk results for this COPEC. Therefore, two sets of HQs for lead are provided, which are designated by the TRV source [i.e., lead (BTAG) and lead (Eco-SSL)]. In addition to assessing site-related exposure to the COPECs, dose modeling was conducted using background soil concentrations in order to determine the potential risk associated with naturally occurring analytes for risk comparisons. Results of the dose assessments using the 95% UCL soil concentrations and the background soil concentrations are summarized in Table ES-2.

As shown in Table ES-2, risks for the majority of the metals detected during the PA/SI are similar to the risks presented from background concentrations, and the background risk is higher than the risk associated with the 95% UCL soil concentration for antimony, cadmium, chromium, copper, mercury, and zinc. Therefore, because the low TRV HQs were either less than 1.0, or less than the respective low TRV HQ for background concentrations, these six metals are not associated with unacceptable risk at the Ballfields Parcels for any of the ROC. Lead and selenium low TRV HQs for the raccoon are less than or at the threshold criterion of 1 and are therefore, not associated with unacceptable risk for this ROC.

For the vole, lead and selenium are the only COPECs with an HQ_{low} greater than one that also is greater than the background HQ_{low}. For the avian receptors, the HQs_{low} for lead (Eco-SSL) are all below 1.0. For lead (BTAG), risks associated with the 95% UCL are less than twice the risk from background concentrations. Note that there are significant differences between the estimates of risk for lead, at times varying by a factor of 100, depending on the specific TRV (i.e., BTAG vs. Eco-SSL) used to estimate risk. For lead, the majority of concentrations detected in surface soil are below the background

Table ES-2. Summary of the Ecological Screening Level Evaluation Using 95% UCL Concentrations

Ecological Risk Evaluation Results			
		HQs_{low} [(a)]	
ROC	COPEC	95% UCL Soil Concentration	Background Soil Concentration
Vole	Antimony	0.14	0.20
	Cadmium	3.12	3.87
	Chromium	0.67	0.99
	Copper	1.33	1.77
	Lead	2.06	1.19
	Mercury	1.65	4.86
	Selenium	2.01	1.03
	Silver	0.002	0.0002
	Thallium	0.003	0.04
	Zinc	2.61	2.95
	2,6-DNT	1.03	ND
	HMX	2.16	ND
Robin (50% Worms + 50% Plants)[(b)]	Cadmium	1.44	1.93
	Chromium	0.96	1.41
	Copper	0.27	0.46
	Lead (EcoSSL)	0.60	0.31
	Lead (BTAG)	68.9	35.5
	Mercury	0.22	0.66
	Selenium	0.08	0.05
	Zinc	0.59	0.64
	Total DDT	3.81	ND
Robin (100% Worms)[(c)]			
	Cadmium	2.62	3.53
	Chromium	1.42	2.09
	Copper	0.33	0.63
	Lead (EcoSSL)	0.92	0.48
	Lead (BTAG)	105	54.3
	Mercury	0.31	0.93
	Selenium	0.12	0.07
	Zinc	1.00	1.08
	Total DDT	7.45	ND
Raccoon	Antimony	0.15	0.21
	Cadmium	2.10	2.81
	Chromium	0.32	0.47
	Copper	0.25	0.43
	Lead	1.05	0.54
	Mercury	0.35	1.04
	Selenium	0.42	0.25
	Silver	0.01	0.001
	Thallium	0.003	0.04
	Zinc	1.15	1.25

Table ES-2. Summary of the Ecological Screening Level Evaluation Using 95% UCL Concentrations (Continued)

Ecological Risk Evaluation Results			
		HQs_{low} (a)	
ROC	COPEC	95% UCL Soil Concentration	Background Soil Concentration
Owl			
	Cadmium	1.76	2.32
	Chromium	1.12	1.63
	Copper	0.56	0.79
	Lead (EcoSSL)	0.75	0.43
	Lead (BTAG)	85.6	49.4
	Mercury	0.32	0.94
	Selenium	0.20	0.13
	Silver	NA	NA
	Thallium	NA	NA
	Zinc	0.94	1.01
	Total DDT	7.01	ND
Harrier			
	Cadmium	0.22	0.26
	Chromium	0.59	0.80
	Copper	0.48	0.54
	Lead (EcoSSL)	0.44	0.30
	Lead (BTAG)	50.4	33.7
	Mercury	0.02	0.07
	Selenium	0.18	0.15
	Zinc	0.54	0.55
	Total DDT	6.88	ND

ND – not determined. Shading indicates HQ_{low}>1.0.

(a) All HQs_{high} are less than 1.0 for all receptors and were therefore not included on this table.

(b) assumes only an omnivorous diet for the robin.

(c) assumes an invertivorous diet for the robin.

concentration of 30.7 mg/kg. Lead concentrations above the 95% UCL soil concentration only were detected in four samples obtained from Revetments 3, 4 and 5, thus showing that the majority of the lead in soil would most likely result in risk consistent with background risk, and depending on which low TRV is used (BTAG vs. Eco-SSL), an HQ_{low} less than 1.0. Based on the low levels of selenium detected at the Ballfields Parcels in conjunction with the fairly representative nature of the concentration distribution, the presence of selenium is most likely naturally occurring and is not anticipated to be associated with unacceptable risk.

For 2,6-DNT, the HQ_{low} is 1.0. For HMX, the HQ_{low} is 2.2. Based on the low magnitude of the HQs_{low}, and the presumptive identification of these two compounds in soil, they are not considered to be of ecological concern at the Ballfields Parcels. As shown in Table ES-2, estimates of risk are above 1.0 for Total DDT. Concentrations of Total DDT in only four surface samples collected from various areas across the site are higher than the 95% UCL soil concentration of 0.12 mg/kg. Concentrations of the other 11 samples collected from the site are anywhere from one to two orders of magnitude less than the 95% UCL. The low TRV HQs based on the 95% UCL soil concentration range from 4 to 8, depending on the ROC (Table ES-2). Because the majority of the Total DDT concentrations in surface soil are much less than the 95% UCL soil concentration, the estimated risks for the ROCs at the site are more likely less than the conservatively estimated HQs_{low} between 4 and 8. As such, exposure to Total DDT at the Ballfields Parcels is not likely to be associated with unacceptable risk for any of the ROC evaluated.

Potential risk to plants was evaluated by comparing maximum concentrations detected to available conservative screening benchmarks. Total DDT, cobalt, lead, mercury, silver, and zinc, exceeded relevant plant screening benchmarks primarily in the former ordnance magazine areas and Revetments 3 and 4. Exceedances may indicate a potential risk to plant communities; however, observations by various investigators of the existing grassland, including the PA/SI sampling crew, suggest that the cover is complete, and there are not obvious indications of stressed vegetation.

Recommendations

Based on the results of the PA/SI and the low magnitude risk presented to human health and ecological receptors, no further action is recommended for the Ballfields Parcels and it is recommended that the Ballfields Parcels be transferred as is to the CCC for seasonal wetlands reuse. Human ingestion of arsenic and vanadium in groundwater is the main risk driver for the residential scenario that was evaluated. Groundwater beneath the site is not currently used for drinking water or any other beneficial uses and likely will not be used in the future; therefore ingestion of groundwater is not a complete exposure route for the more applicable site recreational visitor, or the hypothetical residential receptor evaluated here as a conservative receptor. As such, actual risk to human receptors is well below the levels that have been estimated in this PA/SI Report and no significant threat to human health is associated with chemicals in soil and groundwater at the Ballfields Parcels. Thus, no further action is recommended.

Based on the results of the ecological assessment, the site risk presented by metals in soils is similar to risks presented by background metals concentrations. Concentrations of Total DDT also are associated with elevated HQs_{low} >1.0 for some of the ROCs. However, all conservative dose estimates were well below effects levels based on high TRVs. Although some of the conservative dose estimates were above 1.0 based on the low TRV, low TRVs derived by the BTAG, U.S. EPA Eco-SSL, ORNL, and USACHPPM process represent a no effect level, whereas the high TRVs represent the mid-range of effects levels found in the literature. There is a critical point on the dose-response curve at which effects will first be seen, but that dose is not known. The difference between the low and high TRVs is typically an order of magnitude, and HQs between 1.0 and 10 give an indication of how close the dose may be to the no effect or low effects levels represented by the TRVs. When the difference between the low and high TRV for a COPEC is very great, there is a high degree of uncertainty regarding where effects may first be seen. The difference between the low and high TRVs is greater than two orders of magnitude for some COPECs, such as avian TRVs for Total DDT and lead. A large difference in the high and low TRV for a COPEC increases the uncertainty of risk conclusions based on the magnitude of the low benchmark HQ because it is unknown whether the dose estimated is approaching where first-effects may be found. Given that low TRVs are generally considered to represent no-effect or “safe” levels of exposure below which no effects are expected, and high TRVs are generally considered to represent effect thresholds above which effects may be expected, the magnitude of low TRV HQs and the level of protection indicated by high TRV HQs do not necessarily indicate unacceptable risk for the COPECs listed above.

Therefore, given the uncertainty associated with the interpretation of the conservative estimates of risk when using the low TRVs for Total DDT and lead at the Ballfields Parcels, no further action is recommended for soil.

Section 1.0: INTRODUCTION

A Preliminary Assessment/Site Inspection (PA/SI) for the Ballfields Parcels located at the Department of Defense Housing Facility (DoDHF), Novato, California, was conducted in order to determine whether this property could be readily transferred to the California Coastal Conservancy (CCC) for seasonal wetlands reuse in accordance with the *Hamilton Army Airfield Final Reuse Plan* (Hamilton Local Reuse Authority, 1996). This work was performed for the U.S. Navy under Navy Facilities Engineering Service Center (NFESC) Contract No. N47408-01-D-8270, Delivery Order No. 0063, and is funded by the Engineering Field Division Southwest in San Diego, CA. The U.S. Navy is the lead agency administrating the investigation and characterization of the Ballfields Parcels, and it is Department of Defense (DoD) Policy to achieve site closure with the agreement of local regulatory authorities. The San Francisco Bay Area Regional Water Quality Control Board (RWQCB) and California Department of Toxic Substances Control (DTSC) are involved as the local and state regulatory authorities for the project, respectively. Before property transfer can occur, the Navy is required to confirm that the property does not present an unacceptable threat to human health and/or the environment, and that it is acceptable for its planned future use as a seasonal wetland.

A Background Summary report (Battelle, 2004) was prepared to provide a summary of the site history, setting, and previous environmental investigations conducted in the area of the Ballfields Parcels. This initial research identified particular geographical areas of potential concern (AOPCs) and the presence of area-wide dichlorodiphenyltrichloroethane (DDT) associated with the former Army Base Realignment and Closure (BRAC) property. The AOPCs, as shown on Figure 1, were identified as follows: (1) the presence of two former ordnance magazines (i.e., Buildings 191 and 193), (2) five former airplane revetments, and (3) spoils piles (i.e., Revetment Spoils Pile [RSP] and Spoils Pile N [SPN]) originating from the Perimeter Drainage Ditch (PDD). As a result of the historical records review, certain hazardous substances, in addition to the DDT, were either identified as being present or potentially present at some of the AOPCs based on historical activities that occurred at the AOPC. Therefore, as part of the PA/SI, soil and groundwater samples were collected in April 2005 from these areas to confirm or determine the presence of DDT and other hazardous substances. Based on a request from the Department of Fish and Game, the Navy also included the PDD as an AOPC, and collected soil samples from along the top of the banks of the PDD (Figure 1) to analyze for DDT and metals. Because these AOPCs are known to have been directly associated with former military activities, it is assumed that they will be more likely associated with the highest contaminant concentrations.

This PA/SI report was prepared to address requirements under United States Environmental Protection Agency (U.S. EPA) guidance for a PA (U.S. EPA, 1991, 1992a) and the California DTSC Preliminary Endangerment Assessment (PEA) Guidance Manual (DTSC, 1994). This Final PA/SI report is the revised version of the Draft Final PA/SI report dated February 2006 based on regulatory comments received from DTSC, Department of Fish and Game, and the RWQCB. Appendix L contains the agencies' comments and Navy's responses to comments on the draft and draft final reports. After completing a review of the Draft Final PA/SI report, the state determined that no further action is necessary for the Ballfields Parcels with regard to human health and the environment, and that the parcels are suitable for unrestricted land use. Appendix M contains a copy of the regulatory approval letter of recommendation for no further action.

The main objectives of the PA/SI at the Ballfields Parcels are to determine if (1) historical activities resulted in a release of hazardous substances to the environment; (2) the release poses a significant threat to human health or the environment; and (3) the property is suitable for transfer to the CCC for seasonal wetlands use. Following the Introduction, this PA/SI provides the Site Description and Background in Section 2, the Environmental Setting in Section 3, Sampling Activities and Results in

Section 4, the Human Health and Ecological Evaluations in Sections 5 and 6, respectively, and Conclusions and Recommendations in Section 7. References are provided in Section 8.

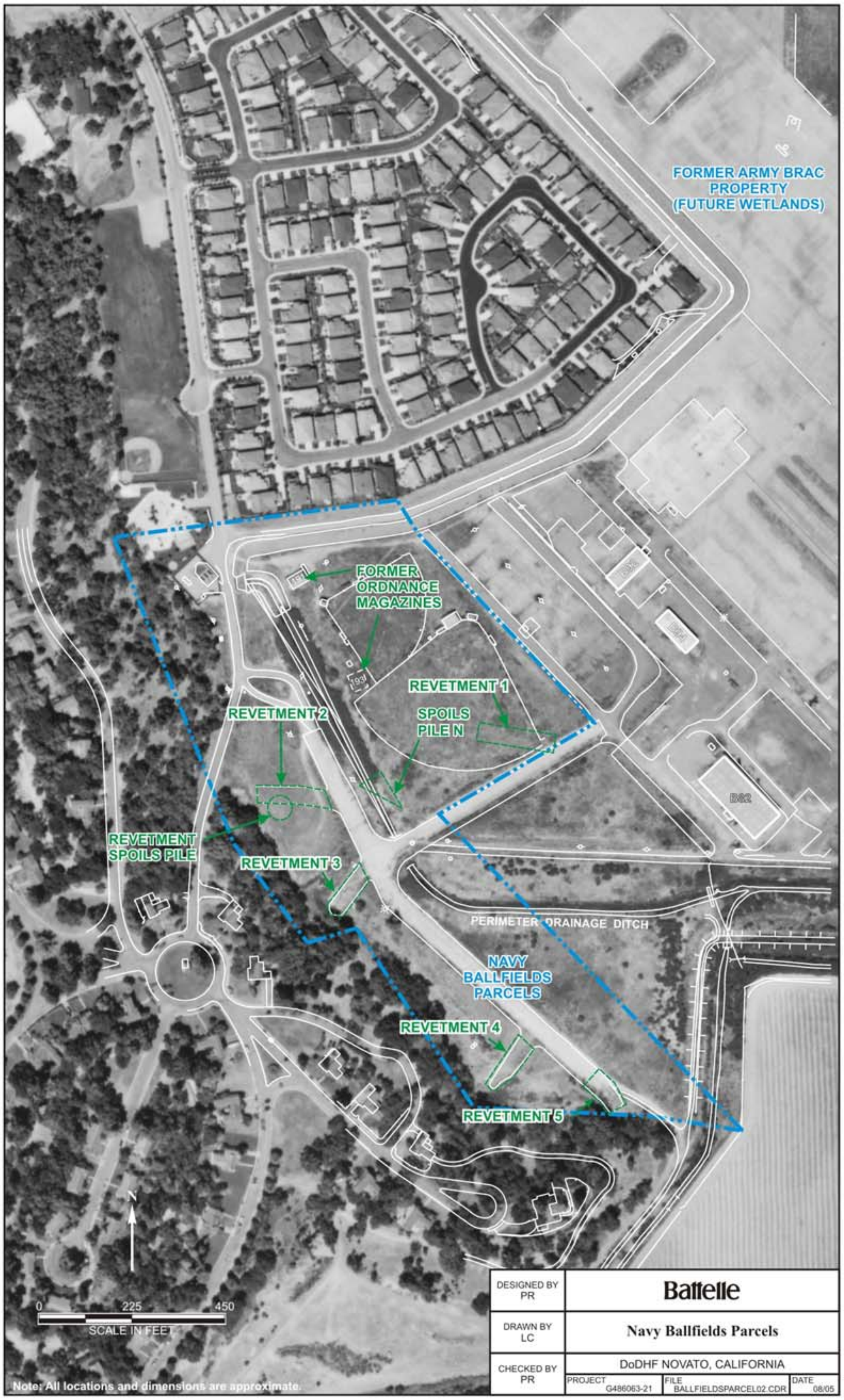


Figure 1. Navy Ballfields Parcels

Section 2.0: BACKGROUND INFORMATION

This section presents all of the available general site background information that is required under U.S. EPA guidance for a PA (U.S. EPA, 1991, 1992) and DTSC guidance for a preliminary endangerment assessment (PEA) (DTSC, 1994).

2.1 Site Identification

The subject site of this report includes Parcels 108A, 110, 112, 114, 115A, and 117 ("Ballfields Parcels") at DoDHF Novato, located approximately 20 miles north of San Francisco in Marin County, CA. The site comprises an area of approximately 18 acres of land bordered by a Coast Guard-owned hillside to the west, a levee and privately owned housing development, South Gate, to the north, and CCC-owned parcels to the south and east (see Figure 1). The site is located within a 100-year floodplain. The mean daily low and high temperatures are 47ºF and 72ºF, respectively. The average annual rainfall is approximately 21 inches, with approximately 4 to 7 inches of rain per month measured between November and March.

2.2 Historical Site Information

In 1932, the U.S. Army Air Corps constructed Hamilton Army Airfield (HAAF) on reclaimed tidal wetland, which had been used as ranch and farm land since the Mexican Land Grant. Military operations began in the area in December 1932. In 1947, HAAF was transferred to the Air Force and renamed Hamilton Air Force Base. The Air Force owned and operated the Base until 1974, at which time it was deactivated. In 1975, residential portions of the Base, which included the Ballfields Site, were transferred to the Navy, and other portions were transferred to the Coast Guard and Army.

The Navy used the Ballfields property as a baseball field and open space starting in 1974, until DoDHF Novato (administered by the Navy) was scheduled for closure under the BRAC program in 1994. Prior to the Navy's use of the Ballfields Parcels, the Air Force performed various military functions such as parking aircrafts at revetments for staging and refueling. The parcels to the south and east were transferred to the CCC from the Army via an early transfer in September, 2003.

The Navy plans to transfer the Ballfields Parcels to the CCC for use in the Hamilton Wetlands Restoration Project. The Hamilton Wetlands Restoration Project includes development of the former Army BRAC property located adjacent to the Ballfields Parcels and San Pablo Bay as tidal wetland and the Navy upland Ballfields Parcels as a seasonal wetland with approximately 6-9 ft of fill placed on top. The Navy's Ballfields Parcels are currently unused by the Navy, but they provide upland habitat and potentially limited seasonal wetland habitat for wildlife.

2.3 Areas of Potential Concern Historical Information

A historical records review of the Ballfields Property was conducted and documented in the Background Summary report (Battelle, 2004). As a result of the records review, particular areas and DDT were identified as potential concerns. A summary of the information obtained during the historical records review is provided below.

2.3.1 Former Ordnance Magazines. Buildings 191 and 193 were built on the Navy's Ballfields Parcels in 1934. Building 191 was built to be a Loading Building Magazine, and Building 193 was designated a Primers and Detonators Magazine (War Department, 1934). Given that building lists are the only known source of information regarding ordnance use, no information about the type of ordnance and/or handling procedures used at Buildings 191 and 193 has been identified. Some information is available about more recent uses of the buildings, including use of Building 193 as a transformer switch station and Building 191 as a staging area for little league baseball teams (ERM-West, 1995).

Building 193 was a 120-square-foot, single-story, windowless brick building on Parcel 114, with a wood-frame roof and concrete floor. Building 193 was formerly used as a transformer vault and switch station as well as an arms and ammunition storage building (ERM-West, 1995), and was demolished sometime between 1997 and 2004 (based on visual observations).

The former ordnance magazines (Buildings 191 and 193) were used for storage of arms and ammunition, not for manufacture or assembly. It is likely that the ordnance was packaged and remained unopened during storage; it is therefore reasonable to assume that no release of ordnance materials occurred in the areas of Buildings 191 and 193. Planned sampling activities at the ordnance buildings were cancelled in 1997 after a BRAC Cleanup Team (BCT) site walk determined that the buildings were in good condition, with no cracks or staining, and a lack of evidence that ordnance had impacted the site (PRC and U&A, 1997). The locations of former Buildings 191 and 193 are shown on Figure 2.

Building 191 was demolished by the CCC in March 2004. The building was a 1,200-square-foot, single-story, windowless concrete block building located on Parcel 112 with corrugated metal roofing and a concrete foundation. It had two large roof vents, heavy steel doors, and loading docks, and was formerly used as a magazine for storage of arms and ammunition (ERM-West, 1995). The building was demolished to the concrete foundation and the area was cleared of all debris.

2.3.2 Former Airplane Revetments. There were five revetments [Revetment 1, Revetment 2, Revetment 3, Revetment 4, and Revetment 5] located on Navy property that were constructed sometime in the late 1930s or early 1940s (Figure 2). Based on aerial photos, it appears that these revetments were actively used from 1943 until 1946 for activities such as aircraft parking, maintenance, and fueling. Throughout the years, the City of Novato has disposed of landscaping and construction debris (including leaves, wood chips, palm fronds, soil, gravel, logs, scrap lumber, asphalt, corrugated metal, and concrete) in the area of some of the former revetments. Prior to PA/SI fieldwork the Navy established an agreement with representatives from the City of Novato that licensed the City to leave the miscellaneous materials on the property through September 2005. In addition, the City of Novato was requested to relocate some of the landscaping and construction debris that was located in areas that were planned for investigation to areas that were not planned for investigation prior to the fieldwork in April 2005.

2.3.3 PDD and Spoils Piles. The PDD is a constructed drainage channel that encircles all but the western margin of the former runway area of HAAF. It was designed to convey surface water runoff to pump stations for lifting and discharge into an outfall drainage ditch and San Pablo Bay. The PDD originates on the Ballfields Parcels and conveys water from portions of the former Army BRAC property as well as from privately owned agricultural lands adjoining the airfield. Approximately 13,500 ft of the PDD is lined with concrete, and 4,000 ft of the PDD is unlined. The entire portion of the PDD on the Navy Ballfields Parcels (1,200 ft) is lined with concrete, and its location can be seen on Figure 3. The inner portion of the PDD is not considered an AOPC because 1) the majority of the water flow comes from a permitted stormwater discharge facility operated by the City of Novato, and 2) all sediments and vegetation were removed from the concrete lining in 1998. However, as a result of a request from the Department of Fish and Game, the Navy has included the top banks of the PDD as an AOPC. In addition, the PDD was periodically dredged in the past to improve flow, and the material removed was typically piled at the edge of the PDD resulting in SPN and the RSP, which are designated as AOPCs. These spoils piles are generally composed of vegetation and sediments. The approximate locations of these spoils piles can be seen on Figure 3.

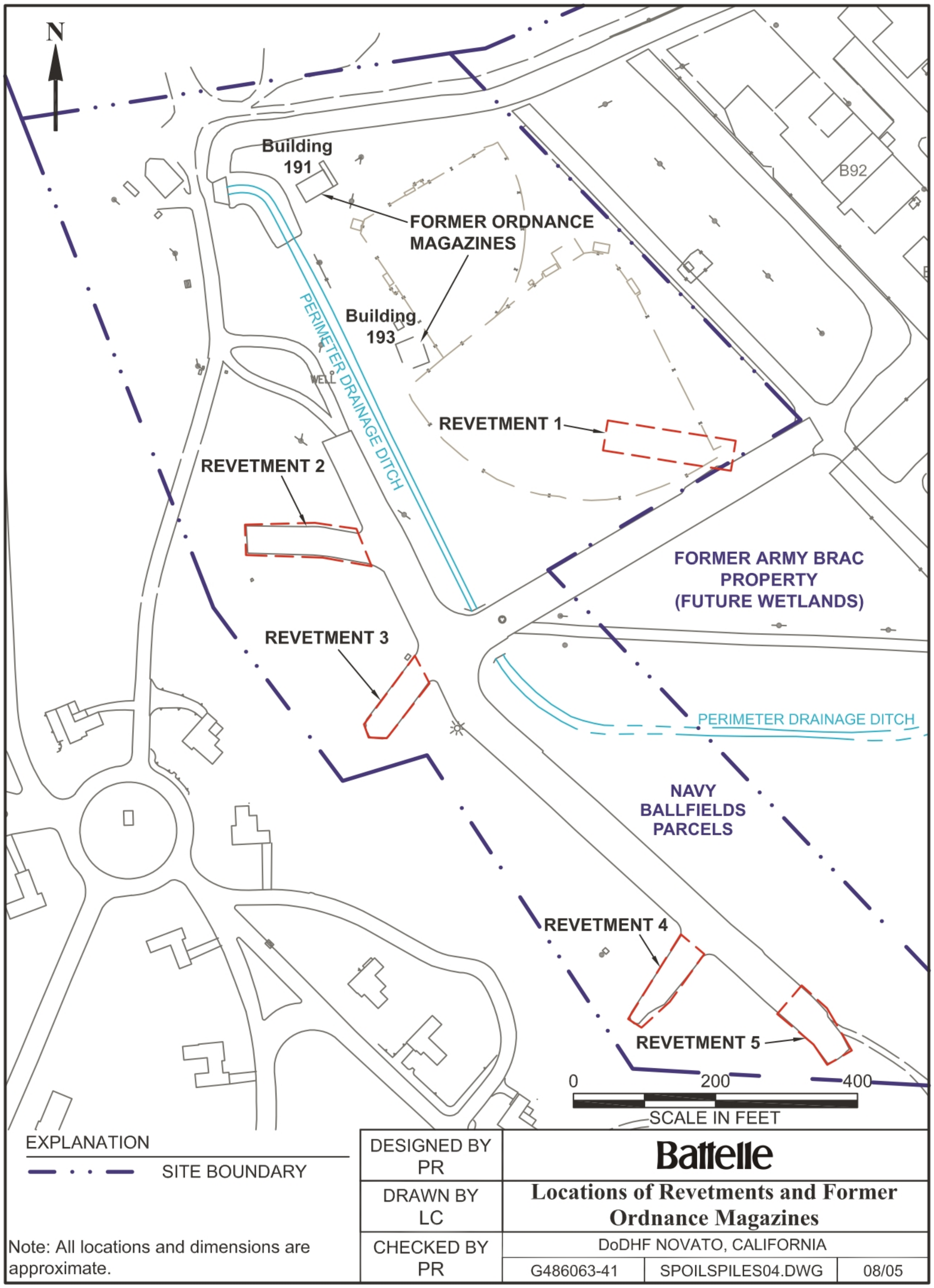


Figure 2. Locations of Revetments and Former Ordnance Magazines

Spoils Pile N (SPN). SPN was composed of sediments and vegetation dredged from the PDD in February 1995. In April 1995, during the Additional Environmental Investigation (WCC, 1996), SPN was sampled and analyzed for metals, polycyclic aromatic hydrocarbons (PAHs), oil and grease, benzene, toluene, ethylbenzene and xylenes (BTEX), total petroleum hydrocarbons as gasoline and diesel (TPH-G and TPH-D, respectively). Metals (lead, cadmium, beryllium, and zinc) were detected above baseline levels established by the Army. As a result of these detections, soil was removed from the footprint of the pile down to the approximate original grade during the 1998 Interim Removal Action (IT, 2000) and disposed of in an off-site Class II facility.

Revetment Spoils Pile (RSP). An additional spoils pile, RSP, was identified on the Ballfields Parcels in early 1995 near the northernmost Navy revetment (see Figure 3). The additional spoils pile is also composed of material dredged from the PDD, but the time of dredging is unknown. In April 1995, one sample was collected and analyzed for metals, PAHs, oil and grease, TPH-D, and TPH-G. Although several metals and PAHs were detected, only lead and benzo(a)pyrene, were detected above U.S. EPA Region 9 residential or California-modified preliminary remediation goals (PRGs).

2.3.4 Area-Wide DDT Issue. This section includes a summary of information associated with the presence of the insecticide DDT and its breakdown products (dichlorodiphenyldichloroethylene [DDE] and dichlorodiphenyldichloroethane [DDD]) in the vicinity of HAAF. According to Army investigations, DDT was used extensively by the military after 1943, mostly to control mosquitoes on Base and delouse aircraft that flew in from tropical regions. An investigation performed by the Army BRAC Program in 1999 (IT, 1999), which included collection of 23 samples from various regions of the site, determined that elevated levels of these insecticides might be present at portions of the airfield.

In March and October 2003, the U.S. Army Corps of Engineers (USACE) conducted an area-wide Total DDT investigation (reported as the sum of 4,4′-DDT, 4,4′-DDD, and 4,4′-DDE) (USACE, 2003) as shown on Figure 4. The investigation focused on determining the Total DDT concentrations in surface and subsurface soils throughout the airfield area, and in identifying the areas of the site with elevated Total DDT concentrations based on samples collected during 1999 (IT, 1999). Using a grid approach, samples were collected from a total of 116 locations (Figure 4) over approximately 600 acres, or one sampling location per 6 acres. As shown on Figure 4, three samples were collected by the Army in 2003 that are located on the Ballfields Parcels (SO-86, SO-87, and SO-88) (USACE, 2003a). Analytical results summarized on Figure 4 show that higher concentrations of Total DDT are present in the shallow soils, and samples collected below the surface have much lower concentrations of Total DDT. The highest historical concentration of Total DDT in soils from the Ballfields Parcels is 0.0651 mg/kg.

Based on the previous sampling, DDT and its breakdown products DDE and DDD are present in soil on the Navy's Ballfields Parcels (USACE, 2003). Both surface and subsurface soil are likely source media for these types of chemicals. Because of the strong adsorption properties of DDT and its breakdown products, it is very unlikely that the chemical would have leached to groundwater. A Record of Decision was developed for the nearby former Army Property (CH2MHill, 2003) which describes a scenario where fill material containing DDT concentrations between 0.024 and 0.93 mg/kg could be placed on the Ballfields Parcels as part of the proposed seasonal wetland design as long as 3 ft of stable cover exists over this soil. Because the Navy's Ballfields Parcels are not available for transfer to the CCC at this time, the subject fill material for the seasonal wetlands restoration project that contains DDT concentrations between 0.024 and 0.93 mg/kg will be placed in another area. This area, referred to as the "Panhandle", has the same planned future use as a seasonal wetland as the Navy's Ballfields Parcels. All fill material is required to meet concentration guidelines for either wetlands foundation or wetlands cover, depending on the final design of the proposed seasonal wetland. The *Draft Staff Report, Beneficial Reuse of Dredged Materials: Sediment Screening and Testing Guidelines* (RWQCB, 2000) gives values for wetlands foundation materials with DDT concentrations up to 0.046 mg/kg.

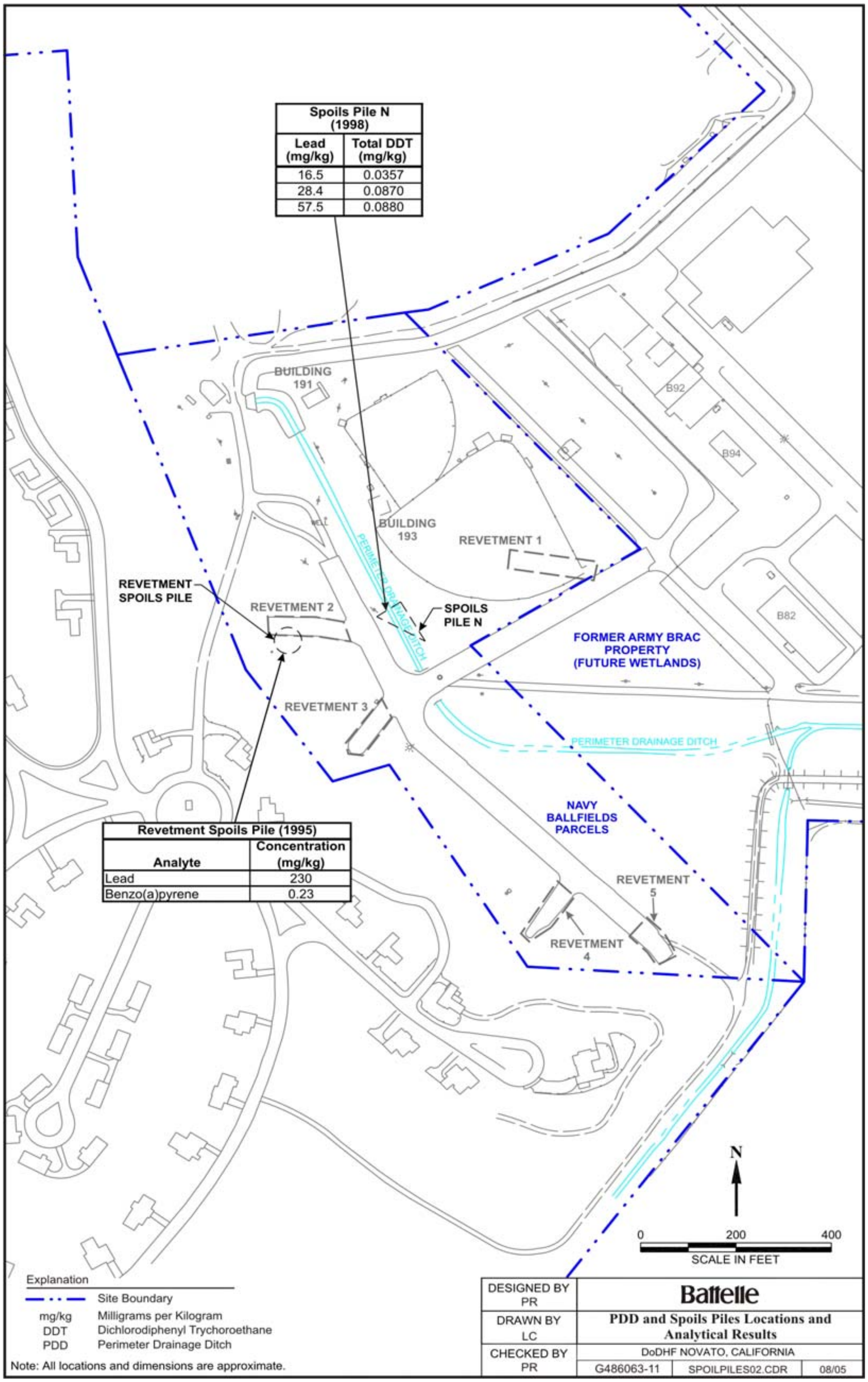
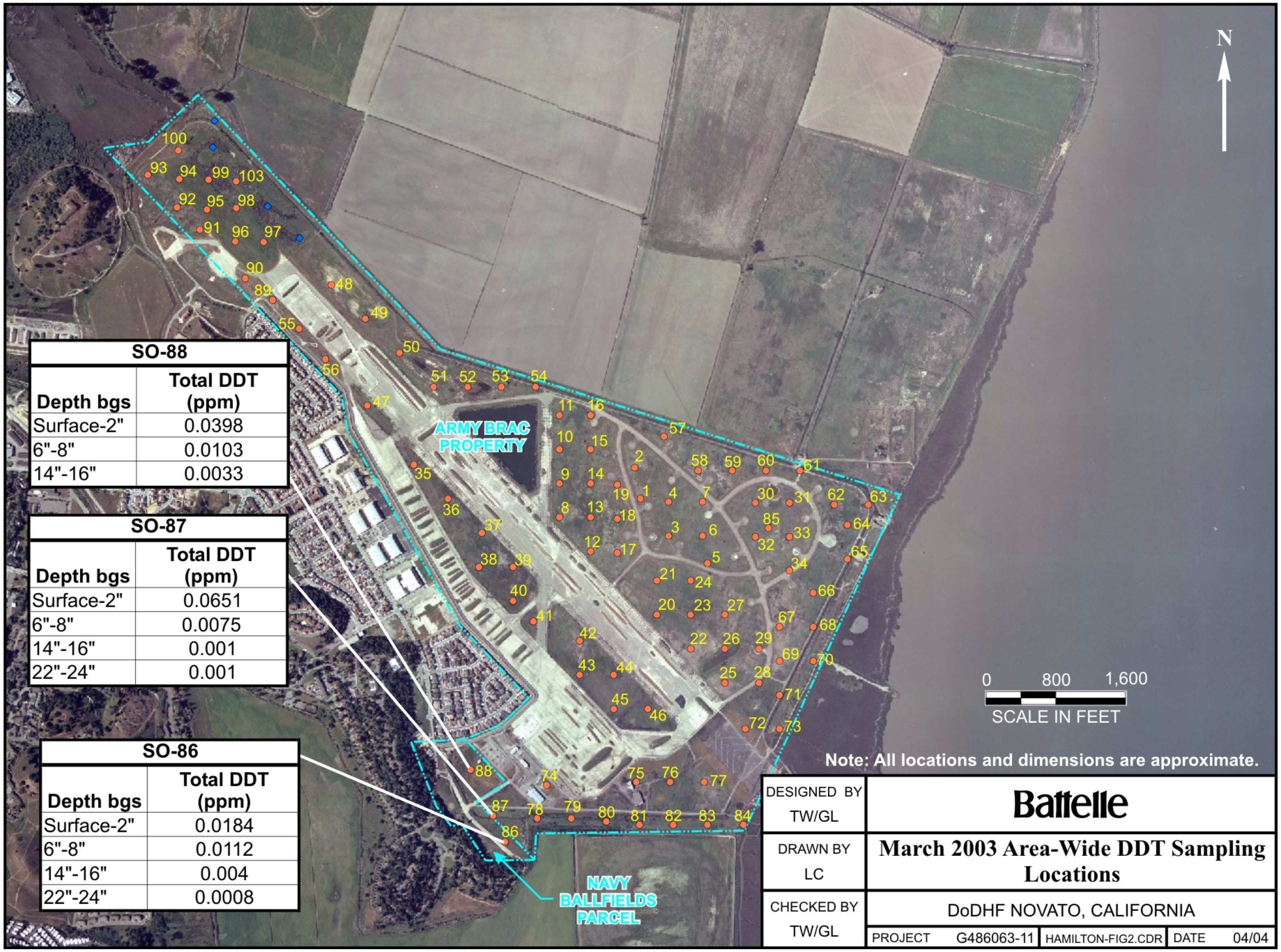


Figure 3. PDD and Spoils Piles Locations and Historical Analytical Results



SO-88	
Depth bgs	Total DDT (ppm)
Surface-2"	0.0398
6"-8"	0.0103
14"-16"	0.0033

SO-87	
Depth bgs	Total DDT (ppm)
Surface-2"	0.0651
6"-8"	0.0075
14"-16"	0.001
22"-24"	0.001

SO-86	
Depth bgs	Total DDT (ppm)
Surface-2"	0.0184
6"-8"	0.0112
14"-16"	0.004
22"-24"	0.0008

Figure 4. March 2003 Area-Wide DDT Sampling Locations and Results for Ballfields Parcels

Section 3.0: ENVIRONMENTAL SETTING

3.1 Hydrogeologic Setting

A description of the hydrogeologic setting at the adjacent former Army BRAC property was presented in the *Main Airfield Parcel Record of Decision/Remedial Action Plan* (ROD/RAP) (CH2MHill, 2003). A summary of that discussion follows.

Three shallow hydrogeologic units occur within the HAAF Main Airfield Parcel and adjacent marsh: fill, soft Bay Mud, and desiccated Bay Mud. The fill originally was used to reclaim the bay margin lowlands for agriculture and has very similar content and hydrogeological properties to the Bay Mud. A different type of fill in the area is the imported construction material used for geotechnical applications and foundation and drainage properties, and is not part of the hydrogeologic unit. This type of fill may be found in pipeline trenches and as a bridging layer beneath some of the formerly developed areas. Groundwater flow at the site is generally to the east towards San Pablo Bay. Permeabilities and groundwater flow characteristics of the hydrogeologic units are summarized below:

- Fill materials have moderate to low hydraulic conductivities ranging from 3.4×10^{-8} to 1.5×10^{-3} cm/sec, indicating minimal groundwater movement. Preferential groundwater flow through the fill may be controlled by the distributions of different fill types.
- Soft Bay Mud generally has low hydraulic conductivity. Preferential flow, if existent, is probably horizontal and confined to peat layers or shell lenses, which are discontinuous.
- Desiccated Bay Mud has low hydraulic conductivity with some fracture permeability. The desiccation cracks are potentially transient in nature and may heal or infill during periods of saturation.

HAAF is located on the eastern side of the Novato Creek groundwater basin and is part of the regional San Pablo groundwater basin defined by the drainage entering San Pablo Bay. San Pablo Bay is approximately 4,530 ft east of the Ballfields Parcels. Existing and potential beneficial uses of groundwater within the Novato Creek basin include municipal and domestic water supply, rare and endangered species preservation, freshwater wildlife habitats, and recreational use (RWQCB, 1995). In 1998, the Army conducted a review of well records from the Department of Water Resources and the Marin County Department of Environmental Health, and found that 11 domestic, industrial and irrigation supply wells exist within a two-mile radius of HAAF. Most of these 11 wells are used for domestic or irrigation supply; all are upgradient of the Airfield Parcel and are therefore isolated from site activities. Only one well is located within 1 mile of the airfield (CH2MHill, 2001).

Groundwater beneath the Main Airfield Parcel and adjacent marsh is not now, nor is it likely to be, used for drinking water. State Water Resources Control Board Policy 88-63 specifies the criteria for determining whether groundwater is a source of drinking water. One of the criteria for suitability as drinking water is low total dissolved solids (TDS). The policy defines water with TDS in excess of 3,000 mg/L unsuitable for drinking. The TDS concentrations in groundwater from monitoring wells across the property range from 819 to 18,270 mg/L with an average TDS concentration of 4,898 mg/L (IT, 1999). The second criterion for a municipal water supply is that the water-bearing zone should provide enough water capable of producing an average, sustained yield of 200 gallons per day to a single well. The sustained yield of the aquifer beneath the BRAC Property has not been measured. Anecdotal information during well sampling suggests that the aquifer is unlikely to have a yield of 200 gallons per day (IT and CH2M Hill, 2001). In general, groundwater in the BRAC Property has a low potential for domestic, agricultural, or industrial use. Groundwater is generally not extracted in the Bay plain east of Novato because of poor water quality, low well yield, decreasing saturated aquifer thickness, and the lack of an adequate confining layer for sanitary well seals. Redevelopment plans for the HAAF include importing municipal water for residential and industrial uses, reducing the necessity of installing any groundwater extraction wells. Well-integrity criteria and potentially rapid degradation of water quality from salinity generally preclude groundwater extraction (IT and CH2MHill, 2001). These findings indicate that groundwater beneath the Main Airfield Parcel and adjacent marsh is generally unsuitable for drinking. Groundwater at the Ballfields Parcels is not currently, nor likely will be used for drinking water due to high TDS, low yield, thin and shallow aquifer conditions that do not allow sufficient thickness for sanitary seal, and the fact that potable water is currently supplied to the area by the City of Novato (IT and CH2M Hill, 2001).

3.2 Geology

The geologic description of the adjacent former Army BRAC property provided in this subsection originates from the *Comprehensive Remedial Investigation Report* (IT, 1999) and is used to summarize the geology for the Ballfields Parcels because of the similarities of the Army BRAC property and the Ballfields Parcels. HAAF lies within the San Francisco-Marin structural block of the northern Coast Range geomorphic province of California. This Coast Range province is characterized by a series of nearly parallel mountain ranges and intermontaine alluvial valleys that trend obliquely to the coastline in a northwesterly direction. The province consists of geologic units composed of a heterogeneous mixture of metamorphosed igneous and sedimentary rock types and exhibit varying degrees of tectonic deformation. These rocks are grouped together as the Franciscan Complex of Jurassic to Cretaceous age and form the bedrock beneath HAAF. The bedrock is locally overlain by Tertiary alluvium and colluvium deposits. Overlying these geologic units are Quaternary Bay Mud and fill.

The higher relief areas to the west and south of the former Army BRAC property are underlain primarily by sandstone of the Franciscan Complex. A clayey, weathered horizon typically overlies the bedrock beneath the Bay Mud deposits. Alluvial/colluvial deposits, composed of sands and silts, are present along the hill slopes and interfinger with Bay Mud in some areas. The Bay Mud, which underlies most of the Bay plain and airfield parcel, is of Quaternary age and typically consists of semiconsolidated to unconsolidated, highly plastic, clayey silt to silty clay, with microscopic organic matter throughout, as well as discrete lenses and beds of peat and occasional shell fragments. The Bay Mud is soft and plastic when moist, but shrinks, hardens, and becomes brittle when dried. The Bay Mud is stiff and desiccated (cracked) from about 3 ft below ground surface (bgs) to a maximum depth of 12 ft bgs (“desiccated Bay Mud”). The desiccated Bay Mud is underlain by saturated Bay Mud (“soft Bay Mud”). The total thickness of Bay Mud increases towards San Pablo Bay and is estimated to be more than 80 ft thick at the eastern edge of the former Army BRAC property.

Fill material overlies the Bay Mud across much of the former Army BRAC property. The fill, consisting of sandy or silty gravel with about 30 percent clay, has an average thickness of 3 ft and a maximum observed thickness of 9 to 10 ft. In general, the fill is thicker near developed areas of the site such as the tarmac, runway, and revetment pad areas. Thickness of the fill in areas of the site away from developed features is typically less than 1 ft.

During PA/SI site investigation and sampling activities, soil cores were classified according to lithology. Appendix A provides the lithologic descriptions for each of the core samples. In general, the lithologic observations made during sampling were in agreement with the geologic descriptions of the surrounding area, consisting largely of fill and bay mud in most locations.

3.3 Surface Water Bodies

HAAF is located in the southern portion of the Novato Creek Drainage Basin and Watershed (CH2MHill, 2003). The main slough channel drainage system in the HAAF area drained to the northwest into the tidal reaches of Novato Creek (PWA, 1998), which then drained into San Pablo Bay. Using a system of levees and drainage ditches, the area that is now HAAF was reclaimed for agricultural use in the late 1800s.

Surface water flow is generally from the upland areas in the west toward San Pablo Bay in the east. From areas west of HAAF, Pacheco Creek and Arroyo San Jose carry surface water along the northwestern boundary of HAAF. Both Pacheco Creek and Arroyo San Jose discharge into the Ignacio Reservoir (also called Pacheco Pond), which occupies approximately 120 acres and has a storage capacity of 480 acre-ft (JSA, 1998b). The Ignacio Reservoir is located just northwest of the northwest property boundary of the former HAAF. The reservoir drains into Novato Creek through a levied channel with a flap-gate outlet located at the Bel Marin Keys Boulevard Bridge.

A man-made PDD runs along three sides of the former Army airfield to convey discharge from the City of Novato's stormwater discharge facility located just north of the Ballfields Parcels to the San Pablo Bay. A short, concrete-lined, 1,200-ft section of the 17,500-ft PDD is located on the Navy Ballfields parcels. The PDD, which originates on the Ballfields Parcels, experiences intermittent flow from the stormwater discharge facility, which may cause minor pooling of surface water. The PDD also receives runoff from surrounding private land.

3.4 Land Use

The 18.37 acres of Navy Ballfields Parcels is currently characterized as a terrestrial, grassland habitat with some developed areas (JSA, 1998b). It is comprised of weedy upland plants such as yellow star thistle and wild radish, as well as grasses such as barley, ryegrass, and tall fescue. Because this area is fragmented by old service roads and the entire parcel encompasses a relatively small area, the quality of wildlife habitat is considered moderate (IT, 1999). The area provides foraging habitat for terrestrial species such as the California vole, raccoons, black-tailed deer, burrowing owls, and northern harriers. Based on biological surveys conducted by the Army BRAC Program and the CCC on the HAAF property, there are no threatened or endangered species or habitats located in the area (Jolliffe, personal communication, 2004).

The *Hamilton Wetland Restoration Plan-Final Environmental Impact Report/Environmental Impact Statement* (JSA, 1998b) states that the Navy Ballfields Parcels will be restored to a seasonal wetland area. This will be achieved by the reuse of suitable dredged material as fill, or cover, and the breach of nearby levees to flood the land. Dredged materials used in the wetland will be suitable for upland beneficial reuse and will comply with regional wetland cover material guidelines as defined by the San Francisco Bay RWQCB (RWQCB, 2000). Using dredged material, the rate of marsh development will be accelerated, making habitat more readily available to fish, wildlife, and species dependent on marsh for survival. The emergent habitat will be part of 570 acres of restored seasonal wetlands that are valued for their scarcity and benefit to federally listed threatened and endangered species (JSA, 1998b). In addition, a public access trail will run adjacent to the Navy Ballfields Parcels, along the western hillside of the parcel and the northern New Hamilton Partners levee. Figure 5 shows the draft proposed seasonal wetlands design for the site.

Current elevation of the Ballfields Parcels is generally between 0 and 3 ft below mean sea level (JSA, 1998a). According to the *Hamilton Wetlands Restoration Plan – Feasibility Study* (JSA, 1998a), an elevation of +6 to +8 ft national geodetic vertical datum (NGVD) 1929 is necessary to establish the seasonal wetland. It is inferred that the amount of fill on the Ballfields Parcels, therefore, will be between 6 and 9 ft. This area will typically not be flooded by the tides. There will be a channel through the seasonal wetlands habitat that will convey the waters discharged from the City of Novato storm water pumping plant located in the northwest corner of the site. The exact design grade of this channel has not yet been determined; however, the channel will likely evolve to be nontidal in the area composing the Ballfields Parcels. These channels will be naturally determined/created.

Although more than 600 acres of land near the Ballfields Parcels will be converted into a seasonal wetlands area, not all wetlands areas will support the same ecological habitat. It is noteworthy that the 18 acres composing the Ballfields Parcels is planned to become a seasonal wetland, with a significant portion of the property not influenced by tidal action.

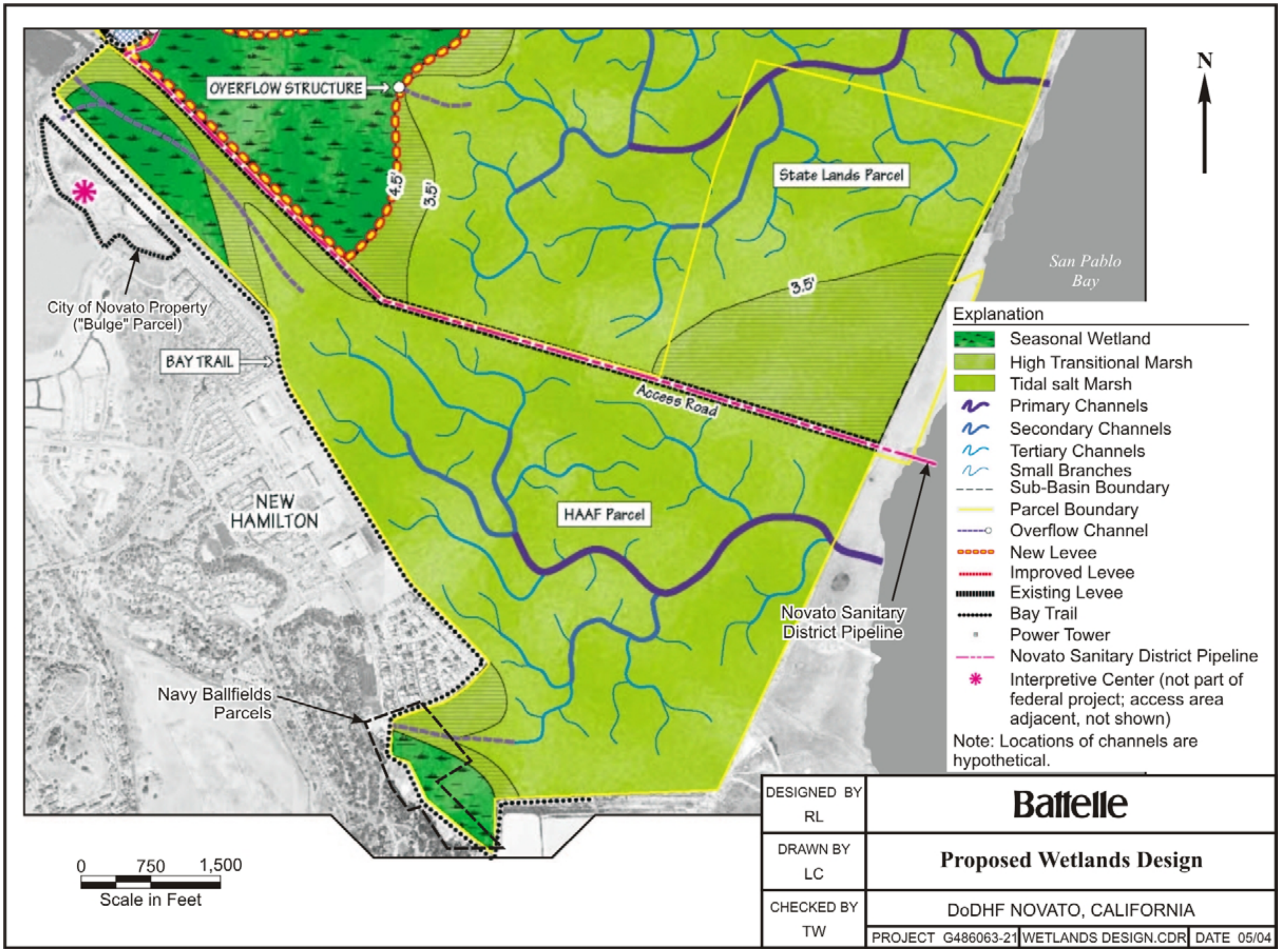


Figure 5. Proposed Wetlands Design

Section 4.0: SAMPLING AND ANALYTICAL RESULTS

4.1 Summary of Sampling Activities

The Navy developed a sampling approach for identifying potential environmental impacts at each of the AOPCs (i.e., Building 191, Building 193, PDD, five Navy revetments, RSP, and SPN). The rationale for the design is described in detail in the PA/SI work plan (Battelle, 2005). Soil and groundwater sampling was performed from April 5 through April 7, 2005, to collect additional analytical data to assess the environmental conditions at the site in order to determine whether ecological or human receptors may be exposed to unacceptable risks due to historical site activities. Samples were labeled by Task Order number, sample location code (see Table 1), soil boring or groundwater location number, sample depth interval (in feet) and, if the sample was a duplicate or quality control (QC) sample, a short description (e.g., TO63-193-SB01-0-0.5). The sampling locations are shown in Figure 6. Note that the Task Order number has not been included in the sample ID on Figure 6. One soil sample, designated as R2-SB01(RSP-SB01) on Figure 6, is a co-located sample that was used to assess both Revetment 2 and the RSP.

Table 1. Sample Location Code Descriptions

Sample Location Code	Description
191	Building 191
193	Building 193
PDD	Perimeter Drainage Ditch
R1	Revetment 1
R2	Revetment 2
R3	Revetment 3
R4	Revetment 4
R5	Revetment 5
RSP	Revetment Spoils Pile
SPN	Spoils Pile N

Table 2 describes the number of samples and analyses that were performed at each AOPC. The laboratory analytical methods for the analyses are listed in Table 3. The following soil and groundwater samples were collected:

- Soil samples were collected from four locations at each Revetment. Two locations had soil samples collected at two discrete depths and two locations had soil samples collected from one depth only (i.e., surface interval). At each of these 16 boring locations, one sample was collected from the surface (i.e., 0-6 inches bgs) and one from the subsurface (i.e., between 1 ft bgs and the top of the groundwater table). The cores were visually inspected for evidence of contamination and PID measurements were taken to screen for volatile organic compounds. If the visual inspection and/or PID screening indicated contamination, a sample was collected from that interval. If there was no evidence of contamination in the subsurface portion of the core, a sample was collected from a depth nearest the groundwater table. No evidence of contamination was observed, nor were any PID measurements above background levels during the entire duration of sampling activities at the Ballfields Parcels; therefore, the subsurface soil sampling interval was collected from the depth nearest the groundwater table in accordance with the Final

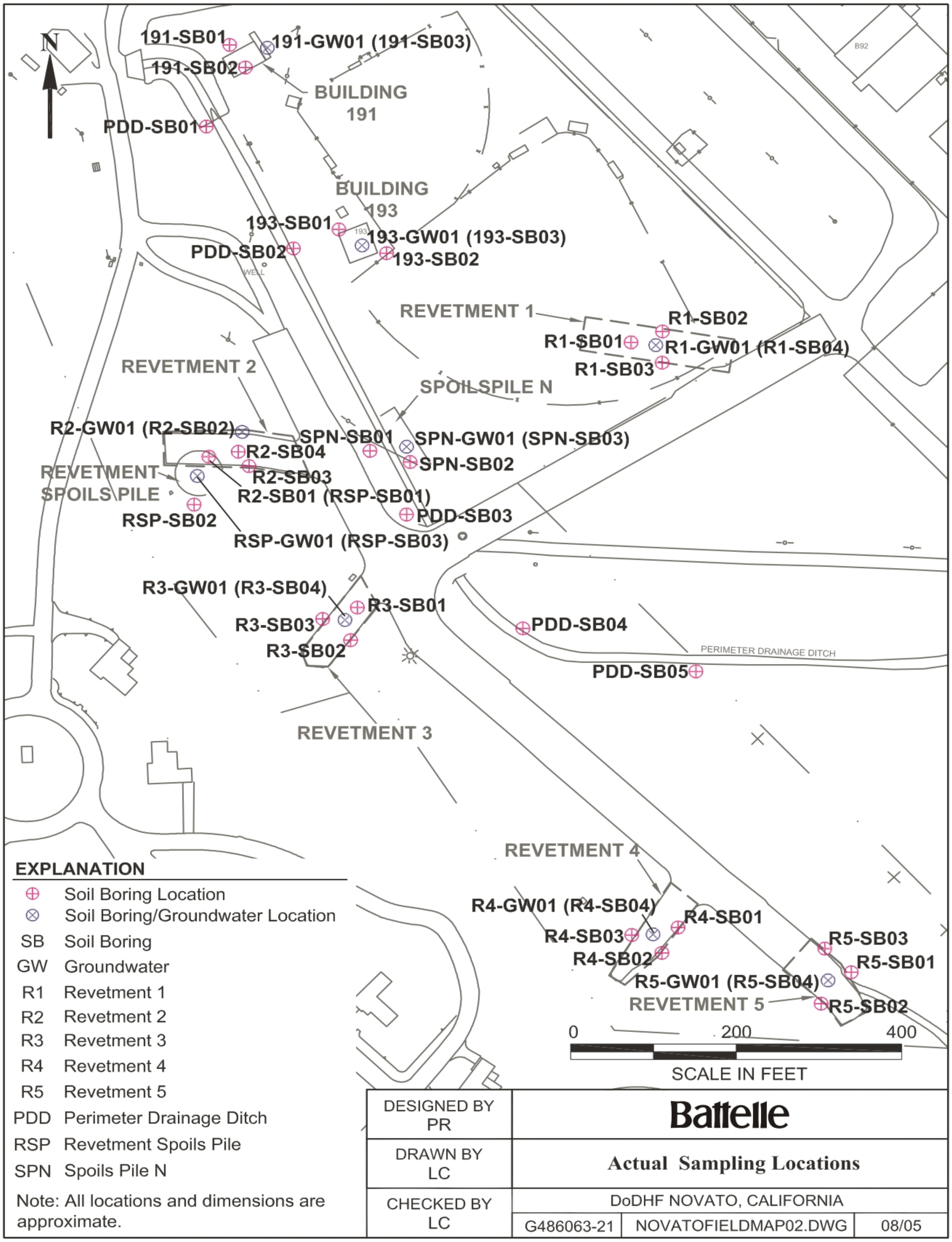


Figure 6. Soil and Groundwater Sampling Locations

Table 2. Sample Plan Details

Location	Sample Matrix	Number of Sample Locations	Total Number of Samples	Analyses
Buildings 191 and 193	Soil	3 per building[(a)]	6	Explosives, CAM 17 metals; PCBs; Total DDT[(b)] in one sample
	Groundwater	1 per building	2	Explosives
PDD	Soil	5	5	Total DDT, CAM 17 metals; PCBs held for potential analysis if found to be appropriate following review of PCB data for samples collected in Bldg 193.
Navy Revetments (5 Revetments)	Soil	4 per revetment[(c)]	30	TPH-D, TPH-G, TPH-RRO, SVOCs (including PAHs), VOCs, CAM 17 metals
	Groundwater	1 per revetment	5	TPH-D, TPH-G, TPH-RRO, SVOCs (including PAHs), VOCs, CAM 17 metals
SPN and RSP	Soil	3 per spoils pile[(a)]	12	SVOCs (including PAHs), CAM 17 metals; and Total DDT.
	Groundwater	1 per spoils pile	2	SVOCs (including PAHs), CAM 17 metals
TOTAL	**Soil**	**36[(a)]**	**51[(a)]**	-
	Groundwater	**9**	**9**	-

CAM – California Administrative Method
DDT – dichlorodiphenyltrichloroethane
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PDD – Perimeter Drainage Ditch
RSP – Revetment Spoils Pile
SPN – Spoils Pile N
SVOC – semivolatile organic compound
TPH-D – total petroleum hydrocarbons as diesel
TPH-G – total petroleum hydrocarbons as gasoline
TPH-RRO – total petroleum hydrocarbons residual range organics
VOC – volatile organic compound

(a) One soil sample location placed within Revetment 2 and the RSP, R2-SB01 (RSP-SB01), was used for both locations; thus the total number of sample locations and samples were reduced by one location and two soil samples.
(b) Total DDT to be reported as the sum of 4,4′-DDT, 4,4′-DDD and 4,4′-DDE.
(c) Samples collected at two depths at two locations.

Sampling and Analysis Plan (SAP) (Battelle, 2005). Groundwater was not encountered at a depth shallower than 2 ft bgs, which is the reason no soil samples were collected between 6 inches and 2 ft bgs. In addition, one groundwater sample was collected at each Revetment. The soil and groundwater samples were analyzed for total petroleum hydrocarbons as gasoline, diesel, and residual range organics (TPH-G, TPH-D, TPH-RRO, respectively); semivolatile organic compounds (SVOCs) (including PAHs); volatile organic compounds (VOCs); and CAM 17 metals.

Table 3. Laboratory Analytical Methods

Analytical Parameter	Sample Matrix	Analytical Method
VOCs	Aqueous	U.S. EPA SW-846 5030B/8260B
SVOCs	Aqueous	U.S. EPA SW-846 3510/8270C
TPH-G	Aqueous	U.S. EPA SW-846 5030B/8015B
TPH-D	Aqueous	U.S. EPA SW-846 3510C/8015M
TPH -RRO	Aqueous	U.S. EPA SW-846 3510C/8015M
CAM 17 Metals	Aqueous	U.S. EPA SW-846 6010B/7470A
Explosives[(a)]	Aqueous	U.S. EPA SW-846 8330
DDT	Soil	U.S. EPA SW-846 8081A
SVOCs	Soil	U.S. EPA SW-846 3545/8270C
TPH-G	Soil	U.S. EPA SW-846 5035/8015B
TPH-D	Soil	U.S. EPA SW-846 3550B/8015M
TPH-RRO	Soil	U.S. EPA SW-846 3550B/8015M
PCBs and DDT[(a)]	Soil	Lauenstein and Cantillo, 1993
CAM 17 Metals	Soil	U.S. EPA SW-846 6010B/7470A
Explosives[(b)]	Soil	U.S. EPA SW-846 8330
VOCs	Soil	U.S. EPA SW-846 5035/8260B

VOCs - volatile organic compounds
SVOCs - semivolatile organic compounds
TPH-G - total petroleum hydrocarbons as gasoline
TPH D – total petroleum hydrocarbons as diesel
TPH-RRO – total petroleum hydrocarbons residual range organics
DDT- dichlorodiphenyltrichloroethane
PCB - polychlorinated biphenyl
CAM – California Administrative Method
(a) PCBs and DDT in soil determined by National Oceanic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) methods. Analysis for DDT included DDE and DDD as well.
(b) Explosives analyzed using EPA Method 8330, which quantifies 14 common explosives, including 2,4,6-trinitrotoluene (2,4,6-TNT), nitrobenzene, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and tetryl.

- Soil samples were collected from the surface (0-6 inches) and at depth (between 2 and 6 ft below ground surface [bgs]) at three borings in each spoils piles (No evidence of contamination was observed, nor were any PID measurements above background levels; therefore, the subsurface soil sampling interval was collected from the depth nearest the groundwater). A groundwater sample also was collected from each spoils pile. The soil and groundwater samples were analyzed for SVOCs (including PAHs) and CAM 17 metals. In addition, three surface soil samples and three subsurface soil samples each were collected from the RSP and the SPN and analyzed for DDT, DDD, and DDE (to determine Total DDT). One soil sample location, which was placed within Revetment 2 and the RSP, was used to characterize both locations (see Figure 6).

- Three soil borings were advanced at Buildings 191 and 193 for analysis of CAM 17 metals and explosives residues. Soil samples were collected from two discrete depths at each boring. In addition, the soil samples collected from Building 193 were analyzed for total polychlorinated biphenyls (PCBs). One groundwater sample was collected at each building and analyzed for explosives.

- Five surface soil samples were collected from along the banks of the PDD to ensure that potential contaminants suspended in surface water have not been deposited along the banks of the PDD. These soil samples were analyzed for DDT and CAM 17 metals and an extra sample was held for potential PCBs analysis in the event that PCBs were detected in the samples collected at Building 193.

4.1.1 Soil Sampling. Soil borings were advanced in the locations identified in Figure 6. The locations of the boreholes and sampling points were determined using a Trimble® WAAS Differential Correction Global Positioning System (GPS). Samples were collected from a surface interval consisting of 0-6 inches bgs, at each soil sample location. At 15 sample locations, a second soil sample was collected between the surface and the top of the groundwater table. Geoprobe® direct push techniques were used to collect all soil samples with the exception of the surface soil samples collected along the bank of the PDD. A hand auger was used to collect the PDD surface soil samples. The direct push method collected continuous cores in 1.25-inch diameter, 4-ft long, clear polyvinyl chloride (PVC) sleeves. The sleeves were extracted from the soil sampler and placed in a clean, dry area covered with plastic for visual inspection.

All soil samples were visually inspected for evidence of contamination and a PID was used to monitor for organic compounds. The results of the visual inspection for lithology and PID screening were noted in the field logbook. The field log sheets are included in Appendix A. No waste material was observed in any of the soil samples during visual inspection and the PID screening did not indicate organics were present. Subsurface soils samples were collected at depth just above the groundwater table in accordance with the work plan (Battelle, 2005). To collect a soil sample, the soil was transferred from the sleeve or bucket auger into a glass jar (or Encore™ samplers for VOC or TPH-G analysis). The remaining soil was used for lithologic logging purposes and then properly disposed. The sample containers for all analyses except PCBs and DDT were sent to Columbia Analytical Services (CAS), a California-certified and Navy-approved laboratory based out of Kelso, WA. Samples requiring PCB and DDT analyses were submitted to Battelle's Duxbury, MA laboratory, which is Navy-approved and has ample experience in analyzing soil and aqueous samples for PCB congeners for other projects in the Bay Area such as former Naval Air Station Alameda and Hunters Point Shipyard. Copies of the chain-of-custody records are included in Appendix B.

4.1.2 Groundwater Sampling. The groundwater sampling conducted at the Ballfields Parcels was accomplished using open boreholes and temporary slotted PVC screen. Groundwater samples were collected from nine soil borings as part of the site assessment at the Ballfields Parcels (see Table 2 and Figure 6). PVC well casing terminating with a 1-ft to 5-ft screen section was lowered into the borehole, and allowed to fill with groundwater to the hydraulic gradeline elevation. The depth to water was measured using an water level indicator and recorded in the field logbook. The range of water levels observed was approximately 3 to 8 ft bgs, with an average depth of 5.5 ft bgs. A small peristaltic pump and dedicated tubing was used to purge the temporary sampling points prior to sampling. Field personnel observed suspended solids in the groundwater samples from each location but purged each sampling location until the groundwater cleared as much as possible and then dispensed the water into the appropriate sample containers based on the type of analysis to be performed. Total metals analysis of groundwater samples was performed and therefore no filtering in the field or laboratory was completed. The groundwater sample containers were sent to CAS in Kelso, WA for analysis. A copy of the chain-of-custody records is included in Appendix B. Field personnel observed suspended solids in the groundwater samples, and field notes indicated groundwater samples were turbid.

4.1.3 Deviations from the Work Plan. Prior to the field investigation, portions of the area to be investigated were being used to store soil originating from a residential development project managed by the City of Novato. Although the bulk of the soil was removed from the investigative area, the area surrounding the Revetment 2 and the RSP was covered with a 1.5- to 2-ft thick layer of soil. Prior to sampling, the nonnative soil was removed with a shovel or with the Geoprobe® sampler until the original ground surface was encountered. The contact between transported material and native surface was obvious in areas where concrete was present; in other locations a change in lithology occurred at approximately the same depth and was used to identify the original ground surface. The surface sample then was collected at the original ground surface interface. Other deviations from the Final Work Plan (Battelle, 2004) are as follows:

- The locations of the soil samples were found using a handheld GPS unit (Trimble® GeoXT™) with submeter accuracy instead of using a professional surveyor.

- A total of 12 soil samples from the spoils piles (6 samples from SPN and 6 samples from the RSP), rather than the 1 sample specified in the work plan, was submitted for DDT analysis (and associated breakdown products). In addition, DDT analysis was reported along with the PCB analysis for 1 soil sample collected at Building 193 (193-SB03-0-0.5).

4.1.4 Disposal of Investigation-Derived Waste. All drill cuttings removed from individual boreholes were placed directly into a 55-gal Department of Transportation approved steel drum. The drum was stored in the fenced yard near the former underground storage tank (UST) Site 957/970. Upon receipt of analytical results from the composite soil samples collected from the drum, which classified the soil as nonhazardous, arrangements were made for disposal by a certified waste-handling contractor. The waste manifests are provided in Appendix B.

Groundwater sampling and equipment decontamination processes generated wastewater. Wastewater was stored in a tank in the fenced yard near former UST Site 957/970 prior to disposal. The method for wastewater disposal was determined based on the groundwater analytical results from groundwater monitoring wells. Based on the results, the wastewater was considered nonhazardous and was transported off site and disposed of by a certified waste-handling contractor. The waste manifests are provided in Appendix B.

4.2 Analytical Results

Summary tables of the analytical results for soil and groundwater samples collected April 5 through April 7, 2005 are provided as Appendix C. General observations of each chemical class that was analyzed during the PA/SI are described below, which used in conjunction with Tables 4 and 5 and Figures 7 and 8, provide a useful overview of the analytical results. Tables 4 and 5 provide descriptive statistics of the chemicals detected in soil and groundwater, respectively, whereas Figures 7 and 8 show the maximum detected concentrations in soil (surface and subsurface soil combined) and groundwater, respectively, for each of the areas sampled. Maximum detected concentrations of naturally occurring chemicals less than background concentrations are not provided on Figure 7 because it is assumed that concentrations below background are not related to previous site activities (Section 4.2.1 below discusses comparison to background concentrations). Note that no chemicals were detected above the method detection limit in groundwater samples collected from the former ordnance magazines (Buildings 191 and 193); therefore, maximum concentrations in groundwater are not shown in these areas on Figure 8.

Explosives. Explosives were only analyzed for at Buildings 191 and 193. Only two explosive chemicals, 2,6-dinitrotoluene (2,6-DNT) and 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane (HMX), were detected in soil at Building 191 and Building 193. Concentrations for both these compounds were very low and were J-qualified as estimated values. No explosive chemicals were detected in groundwater beneath these two AOPCs.

Table 4. Chemicals Detected in Soil on a Site-Wide Basis

Chemical	Minimum Concentration Detected[a] (mg/kg)	Maximum Concentration Detected[a] (mg/kg)	Frequency of Detection[b]	Overall Mean[c] (mg/kg)	95% UCL[c] (mg/kg)
Explosives					
HMX	0.23	0.69	2/7	0.1753	0.7985
2,6-Dinitrotoluene	0.2	0.2	1/6 [d]	0.0825	0.1853
Metals					
Antimony	0.06	0.67	55/55	0.184	0.266
Arsenic	1.45	12.3	55/55	5.033	6.703
Barium	27.2	275	55/55	108.362	150.292
Beryllium	0.2	1.1	55/55	0.691	0.744
Cadmium	0.1	1.4	8/55	0.274	0.437
Chromium	12.6	114	55/55	55.865	77.464
Cobalt	3.1	55.8	54/55	11.266	15.953
Copper	4.5	62	55/55	22.454	30.187
Mercury	0.072	0.482	17/55	0.064	0.112
Nickel	7.57	67	55/55	35.333	38.839
Lead	5.38	234	55/55	26.765	51.024
Selenium	0.1	0.7	53/55	0.341	0.437
Silver	0.026	4.81	54/55	0.532	1.462
Thallium	0.068	0.185	55/55	0.117	0.125
Vanadium	19.4	94.7	55/55	49.337	63.773
Zinc	19.8	157	55/55	68.930	75.832
Semivolatile Organic Compounds					
2-Methylnaphthalene	0.0044	0.0044	1/43	0.0013	0.0020
2,4,5-Trichlorophenol	0.0096	0.0096	1/43	0.0031	0.0048
2-Nitroaniline	0.0053	0.0053	1/43	0.0027	0.0042
Acenaphthylene	0.0032	0.0032	1/43	0.0014	0.0022
Acetophenone	0.022	0.039	4/43	0.0135	0.0208
Anthracene	0.0022	0.0036	2/43	0.0015	0.0023
Benzo(a)anthracene	0.0029	0.014	6/43	0.0022	0.0040
Benzaldehyde	0.011	0.034	11/43	0.0129	0.0195
Benzo(a)pyrene	0.0033	0.016	6/43	0.0030	0.0057
Benzo(b)fluoranthene	0.0046	0.026	7/43	0.0043	0.0081
Benzo(g,h,i)perylene	0.0039	0.022	8/43	0.0043	0.0078
Benzo(k)fluoranthene	0.0032	0.0085	2/43	0.0026	0.0041
Bis(2-ethylhexyl) Phthalate	0.019	0.37	17/43	0.1260	0.2093
Butyl Benzyl Phthalate	0.0022	0.017	5/43	0.0021	0.0040
Caprolactam	0.019	0.019	1/43	0.0119	0.0182
Carbazole	0.0005	0.0025	3/43	0.0013	0.0020
Chrysene	0.0051	0.019	10/43	0.0033	0.0106
Dibenz(a,h)anthracene	0.004	0.004	1/43	0.0022	0.0034
Diethyl Phthalate	0.0053	0.0067	2/43	0.0035	0.0054
Fluoranthene	0.0048	0.022	9/43	0.0038	0.0072
Indeno(1,2,3-cd) pyrene	0.0023	0.02	7/43	0.0028	0.0051
Naphthalene	0.0025	0.0025	2/43	0.0013	0.0020
Phenanthrene	0.0027	0.014	10/43	0.0028	0.0050
Phenol	0.0024	0.014	14/43	0.0037	0.0060

Table 4. Chemicals Detected in Soil on a Site-Wide Basis (Continued)

Chemical	Minimum Concentration Detected[(a)] (mg/kg)	Maximum Concentration Detected[(a)] (mg/kg)	Frequency of Detection[(b)]	Overall Mean[(c)] (mg/kg)	95% UCL[(c)] (mg/kg)
Pyrene	0.0019	0.019	12/43	0.0033	0.0106
Total Petroleum Hydrocarbons					
TPH-DRO	7	33	10/32	5.67	11.03
TPH-RRO	6.9	300	21/32	53.63	86.43
Volatile Organic Compounds					
Acetone	0.027	0.044	3/32	0.0116	0.0196
m,p-Xylenes	0.002	0.002	1/32	0.0011	0.0012
Methylene Chloride	0.0035	0.0035	1/32	0.0019	0.0020
o-Xylenes	0.0011	0.0011	1/32	0.0005	0.0006
Pesticides					
Total DDT[(e)]	0.0002	0.36	18/20	0.0482	0.1051

mg/kg – milligrams per kilogram
HMX – 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane.
TPH DRO – total petroleum hydrocarbons diesel range organics.
TPH RRO – total petroleum hydrocarbons residual range organics.
UCL – upper confidence limit.
DDT – dichlorodiphenyltrichloroethane.
(a) Results summarized are for samples collected April 5-7, 2005 during the PA/SI.
(b) Includes duplicates samples.
(c) Surface and subsurface soil sample results were combined to determine the mean and 95% UCL.
(d) Includes only specific analyses for explosives (SW 8330).
(e) Total DDT is reported as the sum of 4,4′-DDT, 4,4′-DDD and 4,4′-DDE.

Metals. Metals were detected in soil from all ten AOPCs at relatively low concentrations in the majority of the samples. Of the 17 CAM metals analyzed for, molybdenum was the only inorganic chemical not detected in soil. For groundwater, seven of the CAM 17 metals (arsenic, barium, chromium, nickel, lead, vanadium, and zinc) were detected in groundwater samples collected from each AOPC, whereas the other 10 metals were sporadically detected beneath the AOPCs at very low concentrations.

SVOCs. Analyses for SVOCs were required for samples collected from the five revetments, SPN, and the RSP. Low levels of SVOCs, including PAHs, were detected primarily in the surface soil samples collected from each of these AOPCs. Similarly, low levels of PAHs and other SVOCs were detected in groundwater beneath the property at each of the AOPCs .

VOCs. Analyses for VOCs were required for samples collected from the revetments. A few VOCs (acetone, methylene chloride, and xylenes) were detected infrequently and at low concentrations in soil samples collected from three of the revetment areas (Revetments 1, 2, and 5). Several VOCs, primarily used as solvents, were detected at very low levels in groundwater beneath all of the revetments. Toluene was the only VOC detected in groundwater beneath all of the revetments.

TPH. Analyses for TPH were required for samples collected from the revetments. TPH-DRO and RRO were detected in soil at low concentrations from all of the revetments. TPH-GRO was not detected in soil. TPH-GRO was detected in groundwater beneath all of the revetments at low, estimated concentrations. TPH-DRO was detected in groundwater beneath all the revetments except Revetment 1. TPH-RRO was not detected in groundwater.

Table 5. Chemicals Detected in Groundwater on a Site-Wide Basis

Chemical	Minimum Concentration Detected[(a)] (µg/L)	Maximum Concentration Detected[(a)] (µg/L)	Frequency of Detection [(b)]
Metals			
Antimony	0.641	0.838	2/8
Arsenic	5.2	88.7	8/8
Barium	26.5	1740	8/8
Beryllium	0.7	6.1	6/8
Cadmium	5.9	11.9	2/8
Chromium	19.4	320	8/8
Cobalt	37.5	155	3/8
Copper	36.5	245	4/8
Lead	3.95	424	8/8
Mercury	0.13	0.44	4/8
Molybdenum	9.5	9.5	1/8
Nickel	11.6	453	8/8
Selenium	4.1	4.6	2/8
Silver	0.349	1.77	2/8
Thallium	0.336	1.01	2/8
Vanadium	24.8	393	7/8
Zinc	23.7	762	8/8
Semivolatile Organic Compounds			
2,4-Dichlorophenol	0.027	0.03	2/8
2-Methylnaphthalene	0.019	0.13	2/8
4-Chloro-3-methylphenol	0.079	0.12	7/8
4-Chloroaniline	0.027	0.027	1/8
Acetophenone	0.16	0.48	8/8
Benzaldehyde	0.14	1	8/8
Biphenyl	0.05	0.083	2/8
Bis(2-ethylhexyl) Phthalate	0.31	15	3/8
Caprolactam	0.36	2.1	6/8
Fluoranthene	0.03	0.033	2/8
Fluorene	0.056	0.056	1/8
Isophorone	0.23	0.66	6/8
Naphthalene	0.023	0.19	4/8
Phenanthrene	0.018	0.17	6/8
Phenol	0.085	0.085	1/8
Pyrene	0.018	0.046	3/8
Volatile Organic Compounds			
TPH-DRO	26	140	5/6
TPH-GRO	14	33	6/6
1,3-Dichlorobenzene	0.11	0.11	1/6
Benzene	0.15	0.15	1/6
Bromomethane	0.22	0.87	2/6
Trichloroethene	0.27	0.28	2/6
Toluene	0.46	1.1	6/6
cis-1,2-Dichloroethene	6.3	6.5	2/6
trans-1,2-Dichloroethene	0.18	0.19	2/6

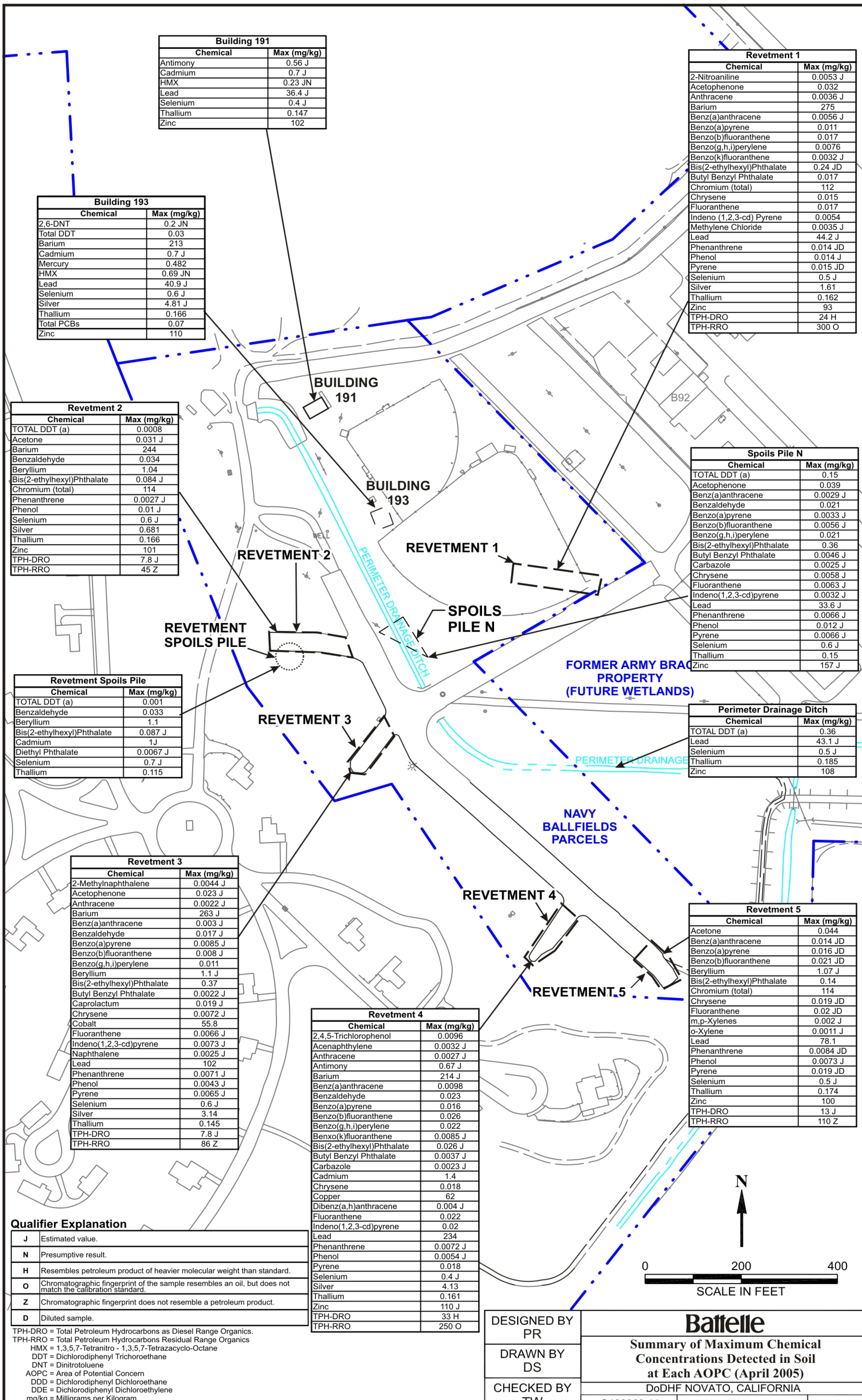
TPH GRO – total petroleum hydrocarbons gasoline range organics.
TPH DRO – total petroleum hydrocarbons diesel range organics.
µg/L – micrograms per liter
(a) Results summarized are for samples collected April 5-7, 2005 during the PA/SI.
(b) Includes duplicates samples.

DDT. Previous investigations of DDT and its breakdown products, DDD and DDE, conducted by Army BRAC (IT, 1999) and the U.S. ACE (2003) at the Ballfields Parcels were summarized in Section 2.34 of this report. The focus of these investigations was on Total DDT, which was derived as the sum of the degradation products 4,4′-DDD, 4,4′-DDE, and 4,4′-DDT. Therefore, in order to be consistent with previous environmental investigations conducted at the Ballfields Parcels, Total DDT, which is calculated as the sum of the degradation products 4,4′-DDD, 4,4′-DDE, and 4,4′-DDT, is actually the chemical of interest for the PA/SI, rather than each of the individual compounds. Note that the results of the soil sampling analysis conducted during the PA/SI also include measurements for 2,4′-DDD, 2,4′-DDE, and 2,4′-DDT (Table C-6 of Appendix C); however, these three isomers were not included in the calculation for Total DDT in order to be consistent with the previous DDT investigations which only summed the 4,4′-isomers.

All three compounds (4,4′-DDD and 4,4′-DDE, and 4,4′-DDT) were primarily detected in surface soil samples collected from the three AOPCs requiring Total DDT analyses (i.e., PDD, SPN, and RSP). Higher concentrations were detected in samples collected along the top of the PDD and SPN as compared to samples collected from the RSP.

PCBs. Soil samples for PCB analyses were collected at former ordnance magazine Building 193 and along the PDD. The samples collected along the PDD were held for analysis until results for Building 193 samples were available. Because PCBs in the Building 193 soil samples were not detected above human or ecological conservative screening criteria of 0.22 mg/kg and 0.371 mg/kg, respectively, the soil samples from along the PDD were not analyzed for PCBs. To demonstrate that Building 193 samples were not detected above human or ecological conservative screening criteria, the PCB congener data were summed and multiplied by 2 to calculate Total PCBs using the method established by the NOAA National Status and Trends (NS&T) Program. There are 18 congeners included on the NS&T list that were selected to represent the major congeners in most coastal environments, and to represent the molecular weight range and different levels of chlorination of PCB congeners (Table 6). These same 18 congeners were summed using the Building 193 data and the summed total was multiplied by 2. As shown in Table 6, the PCB concentrations in Building 193 samples are well below the ecological screening number (0.371 mg/kg) and the U.S. EPA Region 9 Residential PRG (0.22 mg/kg); therefore, there was no evidence of PCB impacts that would warrant additional analyses of soil samples collected along the top of the PDD. The ecological screening number was referenced by Ms. Beckye Stanton of Department of Fish and Game during a teleconference with the Navy and regulatory agencies on February 28, 2005. The human health screening number is U.S. EPA Region 9 Residential PRG (U.S. EPA, 2004).

4.2.1 Comparison to Background for Naturally Occurring Chemicals. Background comparisons were made in accordance with *Selecting Inorganic Constituents as Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities* [California Environmental Protection Agency (Cal-EPA), 1997]. Background soil concentrations were represented by Army BRAC ambient soil data presented in the Final Human Health and Ecological Risk Assessment BRAC Property Hamilton Army Airfield (IT and CH2M Hill, 2001). These background soil concentrations were assumed to be appropriate for use at the Ballfields Parcels because the BRAC property is located adjacent to the Ballfields Parcels where the soil type is similar, consisting of fill, desiccated Bay Mud, and saturated Bay Mud. A total of 38 samples were collected from varying depths at 18 locations from the BRAC property. Because the ambient concentrations of trace elements in these samples were known to vary according to soil type across the site, the trace element results were purposely pooled for all 38 soil samples to provide a larger statistical population (IT and CH2M Hill, 2001). A background soil concentration, identified as the "final ambient comparator", was either the maximum concentration detected or the 95^{th} quantile value of the data. A table summarizing the ambient background data is provided in Appendix E.



Building 191

Chemical	Max (mg/kg)
Antimony	0.56 J
Cadmium	0.7 J
HMX	0.23 JN
Lead	36.4 J
Selenium	0.4 J
Thallium	0.147
Zinc	102

Building 193

Chemical	Max (mg/kg)
2,6-DNT	0.2 JN
Total DDT	0.03
Barium	213
Cadmium	0.7 J
Mercury	0.482
HMX	0.69 JN
Lead	40.9 J
Selenium	0.6 J
Silver	4.81 J
Thallium	0.166
Total PCBs	0.07
Zinc	110

Revetment 1

Chemical	Max (mg/kg)
2-Nitroaniline	0.0053 J
Acetophenone	0.032
Anthracene	0.0036 J
Barium	275
Benz(a)anthracene	0.0056 J
Benzo(a)pyrene	0.011
Benzo(b)fluoranthene	0.017
Benzo(g,h,i)perylene	0.0076
Benzo(k)fluoranthene	0.0032 J
Bis(2-ethylhexyl)Phthalate	0.24 JD
Butyl Benzyl Phthalate	0.017
Chromium (total)	112
Chrysene	0.015
Fluoranthene	0.017
Indeno (1,2,3-cd) Pyrene	0.0054
Methylene Chloride	0.0035 J
Lead	44.2 J
Phenanthrene	0.014 JD
Phenol	0.014 J
Pyrene	0.015 JD
Selenium	0.5 J
Silver	1.61
Thallium	0.162
Zinc	93
TPH-DRO	24 H
TPH-RRO	300 O

Revetment 2

Chemical	Max (mg/kg)
TOTAL DDT (a)	0.0008
Acetone	0.031 J
Barium	244
Benzaldehyde	0.034
Beryllium	1.04
Bis(2-ethylhexyl)Phthalate	0.084 J
Chromium (total)	114
Phenanthrene	0.0027 J
Phenol	0.01 J
Selenium	0.6 J
Silver	0.681
Thallium	0.166
Zinc	101
TPH-DRO	7.8 J
TPH-RRO	45 Z

Spoils Pile N

Chemical	Max (mg/kg)
TOTAL DDT (a)	0.15
Acetophenone	0.039
Benz(a)anthracene	0.0029 J
Benzaldehyde	0.021
Benzo(a)pyrene	0.0033 J
Benzo(b)fluoranthene	0.0056 J
Benzo(g,h,i)perylene	0.021
Butyl Benzyl Phthalate	0.0046 J
Carbazole	0.0025 J
Chrysene	0.0058 J
Fluoranthene	0.0063 J
Indeno(1,2,3-cd)pyrene	0.0032 J
Lead	33.6 J
Phenanthrene	0.0066 J
Phenol	0.012 J
Pyrene	0.0066 J
Selenium	0.6 J
Thallium	0.15
Zinc	157 J

Revetment Spoils Pile

Chemical	Max (mg/kg)
TOTAL DDT (a)	0.001
Benzaldehyde	0.033
Beryllium	1.1
Bis(2-ethylhexyl)Phthalate	0.087 J
Cadmium	1J
Diethyl Phthalate	0.0067 J
Selenium	0.7 J
Thallium	0.115

Perimeter Drainage Ditch

Chemical	Max (mg/kg)
TOTAL DDT (a)	0.36
Lead	43.1 J
Selenium	0.5 J
Thallium	0.185
Zinc	108

Revetment 3

Chemical	Max (mg/kg)
2-Methylnaphthalene	0.0044 J
Acetophenone	0.023 J
Anthracene	0.0022 J
Barium	263 J
Benz(a)anthracene	0.003 J
Benzaldehyde	0.017 J
Benzo(a)pyrene	0.0085 J
Benzo(b)fluoranthene	0.008 J
Benzo(g,h,i)perylene	0.011
Beryllium	1.1 J
Bis(2-ethylhexyl)Phthalate	0.37
Butyl Benzyl Phthalate	0.0022 J
Caprolactum	0.019 J
Chrysene	0.0072 J
Cobalt	55.8
Fluoranthene	0.0066 J
Indeno(1,2,3-cd)pyrene	0.0073 J
Naphthalene	0.0025 J
Lead	102
Phenanthrene	0.0071 J
Phenol	0.0043 J
Pyrene	0.0065 J
Selenium	0.6 J
Silver	3.14
Thallium	0.145
TPH-DRO	7.8 J
TPH-RRO	86 Z

Revetment 4

Chemical	Max (mg/kg)
2,4,5-Trichlorophenol	0.0096
Acenaphthylene	0.0032 J
Anthracene	0.0027 J
Antimony	0.67 J
Barium	214 J
Benz(a)anthracene	0.0098
Benzaldehyde	0.023
Benzo(a)pyrene	0.016
Benzo(b)fluoranthene	0.026
Benzo(g,h,i)perylene	0.022
Benxo(k)fluoranthene	0.0085 J
Bis(2-ethylhexyl)Phthalate	0.026 J
Butyl Benzyl Phthalate	0.0037 J
Carbazole	0.0023 J
Cadmium	1.4
Chrysene	0.018
Copper	62
Dibenz(a,h)anthracene	0.004 J
Fluoranthene	0.022
Indeno(1,2,3-cd)pyrene	0.02
Lead	234
Phenanthrene	0.0072 J
Phenol	0.0054 J
Pyrene	0.018
Selenium	0.4 J
Silver	4.13
Thallium	0.161
Zinc	110 J
TPH-DRO	33 H
TPH-RRO	250 O

Revetment 5

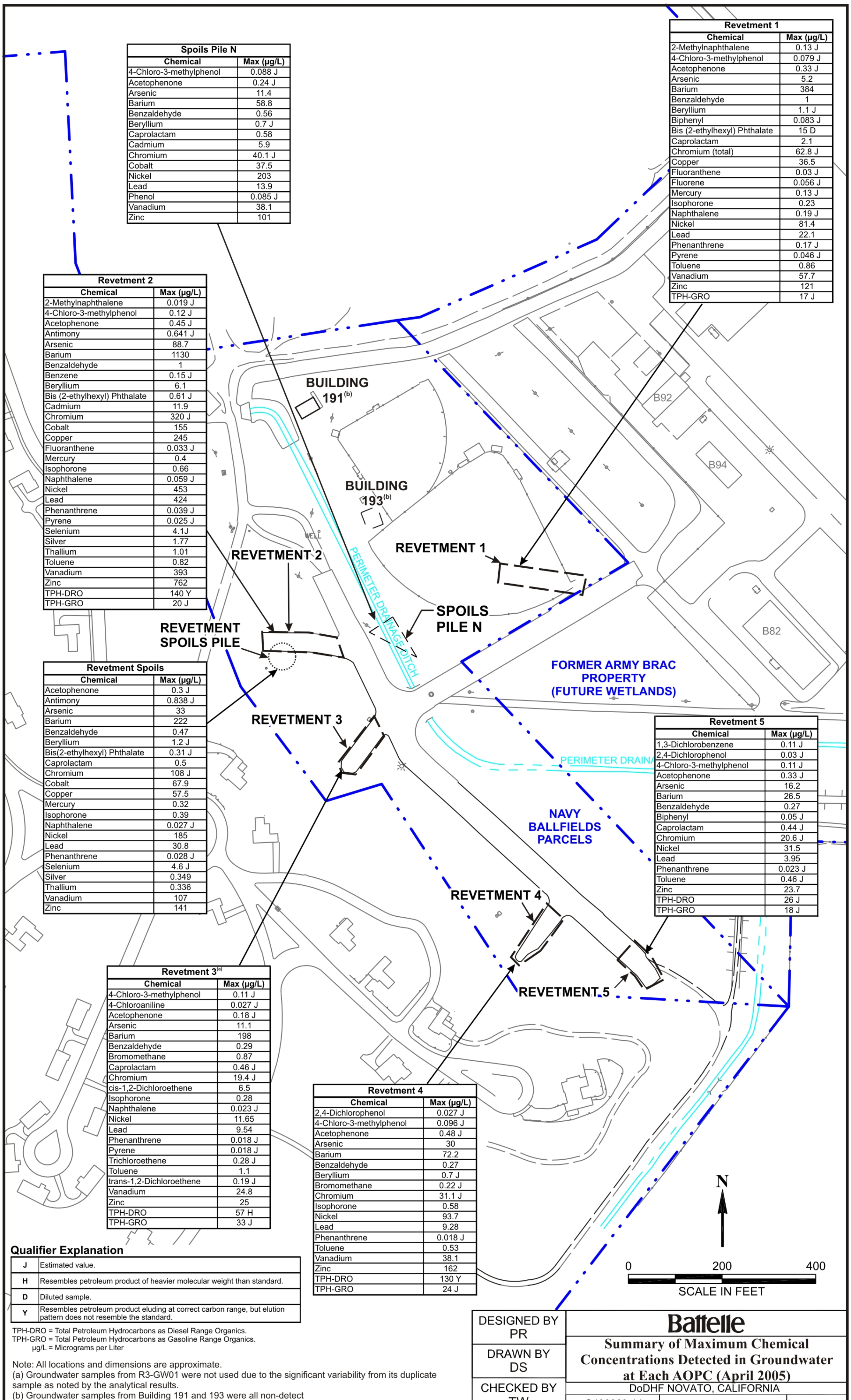
Chemical	Max (mg/kg)
Acetone	0.044
Benz(a)anthracene	0.014 JD
Benzo(a)pyrene	0.016 JD
Benzo(b)fluoranthene	0.021 JD
Beryllium	1.07 J
Bis(2-ethylhexyl)Phthalate	0.14
Chromium (total)	114
Chrysene	0.019 JD
Fluoranthene	0.02 JD
m,p-Xylenes	0.002 J
o-Xylene	0.0011 J
Lead	78.1
Phenanthrene	0.0084 JD
Phenol	0.0073 J
Pyrene	0.019 JD
Selenium	0.5 J
Thallium	0.174
Zinc	100
TPH-DRO	13 J
TPH-RRO	110 Z

Qualifier Explanation

J	Estimated value.
N	Presumptive result.
H	Resembles petroleum product of heavier molecular weight than standard.
O	Chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Z	Chromatographic fingerprint does not resemble a petroleum product.
D	Diluted sample.

TPH-DRO = Total Petroleum Hydrocarbons as Diesel Range Organics.
TPH-RRO = Total Petroleum Hydrocarbons Residual Range Organics
HMX = 1,3,5,7-Tetranitro - 1,3,5,7-Tetrazacyclo-Octane
DDT = Dichlorodiphenyl Trichoroethane
DNT = Dinitrotoluene
AOPC = Area of Potential Concern
DDD = Dichlorodiphenyl Dichloroethane
DDE = Dichlorodiphenyl Dichloroethylene
mg/kg = Milligrams per Kilogram
(a) = Sum of DDT, DDE, and DDD

Figure 7. Summary of Maximum Chemical Concentrations Detected in Soil at Each AOPC



Spoils Pile N	
Chemical	Max (µg/L)
4-Chloro-3-methylphenol	0.088 J
Acetophenone	0.24 J
Arsenic	11.4
Barium	58.8
Benzaldehyde	0.56
Beryllium	0.7 J
Caprolactam	0.58
Cadmium	5.9
Chromium	40.1 J
Cobalt	37.5
Nickel	203
Lead	13.9
Phenol	0.085 J
Vanadium	38.1
Zinc	101

Revetment 1	
Chemical	Max (µg/L)
2-Methylnaphthalene	0.13 J
4-Chloro-3-methylphenol	0.079 J
Acetophenone	0.33 J
Arsenic	5.2
Barium	384
Benzaldehyde	1
Beryllium	1.1 J
Biphenyl	0.083 J
Bis (2-ethylhexyl) Phthalate	15 D
Caprolactam	2.1
Chromium (total)	62.8 J
Copper	36.5
Fluoranthene	0.03 J
Fluorene	0.056 J
Mercury	0.13 J
Isophorone	0.23
Naphthalene	0.19 J
Nickel	81.4
Lead	22.1
Phenanthrene	0.17 J
Pyrene	0.046 J
Toluene	0.86
Vanadium	57.7
Zinc	121
TPH-GRO	17 J

Revetment 2	
Chemical	Max (µg/L)
2-Methylnaphthalene	0.019 J
4-Chloro-3-methylphenol	0.12 J
Acetophenone	0.45 J
Antimony	0.641 J
Arsenic	88.7
Barium	1130
Benzaldehyde	1
Benzene	0.15 J
Beryllium	6.1
Bis (2-ethylhexyl) Phthalate	0.61 J
Cadmium	11.9
Chromium	320 J
Cobalt	155
Copper	245
Fluoranthene	0.033 J
Mercury	0.4
Isophorone	0.66
Naphthalene	0.059 J
Nickel	453
Lead	424
Phenanthrene	0.039 J
Pyrene	0.025 J
Selenium	4.1J
Silver	1.77
Thallium	1.01
Toluene	0.82
Vanadium	393
Zinc	762
TPH-DRO	140 Y
TPH-GRO	20 J

Revetment Spoils	
Chemical	Max (µg/L)
Acetophenone	0.3 J
Antimony	0.838 J
Arsenic	33
Barium	222
Benzaldehyde	0.47
Beryllium	1.2 J
Bis(2-ethylhexyl) Phthalate	0.31 J
Caprolactam	0.5
Chromium	108 J
Cobalt	67.9
Copper	57.5
Mercury	0.32
Isophorone	0.39
Naphthalene	0.027 J
Nickel	185
Lead	30.8
Phenanthrene	0.028 J
Selenium	4.6 J
Silver	0.349
Thallium	0.336
Vanadium	107
Zinc	141

Revetment 3[a]	
Chemical	Max (µg/L)
4-Chloro-3-methylphenol	0.11 J
4-Chloroaniline	0.027 J
Acetophenone	0.18 J
Arsenic	11.1
Barium	198
Benzaldehyde	0.29
Bromomethane	0.87
Caprolactam	0.46 J
Chromium	19.4 J
cis-1,2-Dichloroethene	6.5
Isophorone	0.28
Naphthalene	0.023 J
Nickel	11.65
Lead	9.54
Phenanthrene	0.018 J
Pyrene	0.018 J
Trichloroethene	0.28 J
Toluene	1.1
trans-1,2-Dichloroethene	0.19 J
Vanadium	24.8
Zinc	25
TPH-DRO	57 H
TPH-GRO	33 J

Revetment 4	
Chemical	Max (µg/L)
2,4-Dichlorophenol	0.027 J
4-Chloro-3-methylphenol	0.096 J
Acetophenone	0.48 J
Arsenic	30
Barium	72.2
Benzaldehyde	0.27
Beryllium	0.7 J
Bromomethane	0.22 J
Chromium	31.1 J
Isophorone	0.58
Nickel	93.7
Lead	9.28
Phenanthrene	0.018 J
Toluene	0.53
Vanadium	38.1
Zinc	162
TPH-DRO	130 Y
TPH-GRO	24 J

Revetment 5	
Chemical	Max (µg/L)
1,3-Dichlorobenzene	0.11 J
2,4-Dichlorophenol	0.03 J
4-Chloro-3-methylphenol	0.11 J
Acetophenone	0.33 J
Arsenic	16.2
Barium	26.5
Benzaldehyde	0.27
Biphenyl	0.05 J
Caprolactam	0.44 J
Chromium	20.6 J
Nickel	31.5
Lead	3.95
Phenanthrene	0.023 J
Toluene	0.46 J
Zinc	23.7
TPH-DRO	26 J
TPH-GRO	18 J

Qualifier Explanation

J	Estimated value.
H	Resembles petroleum product of heavier molecular weight than standard.
D	Diluted sample.
Y	Resembles petroleum product eluding at correct carbon range, but elution pattern does not resemble the standard.

TPH-DRO = Total Petroleum Hydrocarbons as Diesel Range Organics.
TPH-GRO = Total Petroleum Hydrocarbons as Gasoline Range Organics.
µg/L = Micrograms per Liter

Note: All locations and dimensions are approximate.
(a) Groundwater samples from R3-GW01 were not used due to the significant variability from its duplicate sample as noted by the analytical results.
(b) Groundwater samples from Building 191 and 193 were all non-detect

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DRAWN BY DS	Summary of Maximum Chemical Concentrations Detected in Groundwater at Each AOPC (April 2005)		
	DoDHF NOVATO, CALIFORNIA		
CHECKED BY TW	G486063-11	SPOILPILES03.CDR	08/05

Figure 8. Summary of Maximum Chemical Concentrations Detected in Groundwater at Each AOPC

Table 6. Derivation of Total PCB Concentrations and Comparison to Screening Criteria

PCB Congener[(a)] (congener number)[(b)]	Units[(c)]	Building 193 Sample ID SB01 (0-6 inches bgs) RESULT	Building 193 Sample ID SB03 (0-6 inches bgs) RESULT	Building 193 Sample ID SB03 (Duplicate Sample) (0-6 inches bgs) RESULT	Building 193 Sample ID SB02 (0-6 inches bgs) RESULT
2,4′-Dichlorobiphenyl (8)	ng/g	0.21 U	0.21 U	0.20 U	0.19 U
2,2’,5-Trichlorobiphenyl (18)	ng/g	0.11 U	0.11 U	0.10 U	0.10 U
2,4,4′-Trichlorobiphenyl (28)	ng/g	0.44 U	0.42 U	0.40 U	0.38 U
2,2',3,5′-Tetrachlorobiphenyl (44)	ng/g	0.08 U	0.32	0.47	0.07 U
2,2',5,5′-Tetrachlorobiphenyl (52)	ng/g	0.06 U	1.08	1.38	0.05 U
2,3',4,4′-Tetrachlorobiphenyl (66)	ng/g	0.09 U	0.09 U	0.15	0.08 U
2,2',4,5,5′-Pentachlorobiphenyl (101)	ng/g	0.04 U	4.85	5.60	0.03 U
2,3,3',4,4′-Pentachlorobiphenyl (105)	ng/g	0.03 U	1.26	1.55	0.02 U
2,3',4,4',5-Pentachlorobiphenyl (118)	ng/g	0.02 U	3.35	4.03	0.02 U
2,2',3,3',4,4′-Hexachlorobiphenyl (128)	ng/g	0.04 U	1.20	1.39	0.03 U
2,2',3,4,4',5′-Hexachlorobiphenyl (138)	ng/g	0.34	6.74	7.86	0.56 U
2,2',4,4',5,5′-Hexachlorobiphenyl (153)	ng/g	0.22	6.98	7.88	0.02 U
2,2',3,3',4,4',5-Heptachlorobiphenyl (170)	ng/g	0.02 U	1.06	1.13	0.02 U
2,2',3,4,4',5,5′-Heptachlorobiphenyl (180)	ng/g	0.14	1.67	1.90	0.02 U
2,2',3,4',5,5',6-Heptachlorobiphenyl (187)	ng/g	0.07 J	0.91	1.07	0.02 U
2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)	ng/g	0.03 U	0.28	0.36	0.03 U
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)	ng/g	0.05 U	0.47	0.59	0.04 U
Decachlorobiphenyl (209)	ng/g	0.05 U	0.32	0.39	0.04 U
Total PCBs[(d)]	**ng/g**	**1.54**	**60.98**	**71.50**	**0.56 U**
Total PCBs[(d)]	**mg/kg**	**0.00154**	**0.06098**	**0.0715**	**0.00056 U**
Eco Screening Number[(e)]	mg/kg	0.371	0.371	0.371	0.371
Human Health Screening Number[(f)]	mg/kg	0.22	0.22	0.22	0.22

(a) International Union of Pure and Applied Chemistry (IUPAC) nomenclature
(b) Congener number is identical to that published by Ballschmiter et al., 1992.
(c) All results are based on dry weight.
(d) Total PCBs calculated by summing NOAA Status and Trends (NS&T) 18 PCB congeners and multiplying by 2.
(e) Ecological screening number was referenced by Ms. Beckye Stanton of Department of Fish and Game during a teleconference with the Navy and regulatory agencies on February 28, 2005. The screening number was obtained from Effroymson et al., 1997b.
(f) Human health screening number is U.S. EPA Region 9 Residential PRG.

PCB = polychlorinated biphenyls
ng/g = nanograms/gram.
mg/kg = milligrams/kilogram.
J = Estimated value.
NA = Not applicable.
U = Chemical not detected above the method detection limit.

Comparisons of the naturally occurring inorganic chemicals detected at the Ballfields Parcels were compared to background soil concentrations (Table 7). Maximum concentrations detected that were less than the background soil concentration (i.e., final ambient comparator) were determined to be consistent with background conditions, and not related to historical activities at the Ballfields Parcels. Table 7 provides the site-wide background comparison. The site-wide comparison consisted of combining data collected from each of the AOPCs to form one dataset and then selecting the maximum concentration for each of the inorganic chemicals. Results of the site-wide background comparison will be used in the human health screening-level and ecological risk evaluations (Sections 5 and 6). Shaded concentrations on Table 7 indicate that the maximum concentration was below the background concentration and therefore the inorganic chemical was not included in the human health screening-level or ecological risk evaluation. Concentrations in bold indicate exceedances of background values and identify those metals that will be evaluated in the screening assessments. Background concentrations for groundwater were not available; therefore inorganic chemicals detected in groundwater were not eliminated based on a background comparison. The maximum concentrations of naturally occurring chemicals detected in soil that are less than background thresholds are not shown on Figure 7.

Also shown in Table 7 are the sediment acceptance criteria from the Hamilton Wetland Restoration Project (HWRP) (RWQCB, 2005) as another point of comparison. Note that except for lead and silver, maximum concentrations are generally less than or consistent with the HWRP sediment criteria for which there are detected concentrations.

4.3 Data Quality Assurance/Quality Control Summary

The general quality of the analytical data generated as part of this effort was examined for its overall adherence to the quality assurance/quality control (QA/QC) program outlined in the project work plan (Battelle, 2005). A three-fold examination was performed to ensure that (1) the data were correctly analyzed, (2) the results were correctly reported, and (3) data outside the stated QA/QC limits were properly flagged.

4.3.1 Data Verification. The data were checked and flagged by the respective laboratories for adherence to laboratory QC procedures. In addition, the data generated for Novato Ballfields Parcels were verified by the Battelle Project QC Manager. Data verification involved ensuring that the holding times (HT) were met and samples were analyzed according to the frequency and methodology specified in the SAP.

All sample analyses were conducted within the specified HTs. Samples were analyzed according to the frequency and methodology specified in the SAP except for deviations listed in Section 4.1.3. Field duplicates were analyzed and generally had similar results with the exception of R3-GW01-DUP and R3-GW01 for metals. According to the laboratory, the analytical results for these samples were significantly different. An inspection of the sample bottles by the laboratory showed that R3-GW01 was visibly different from the duplicate sample because it contained more particulate material (i.e., was more turbid). Thus, the analyses in the more turbid sample were most likely impacted by the presence of all the particulates resulting in the huge variability of metals concentrations between the two water samples.

Elevated method detection limits (MDLs) for 2,4-dimethylphenol, 2,4-dinitrophenol, and 2-chloronaphthalene were reported for soil samples collected from R1-SB01-0-0.5, R1-SB04-0-0.5, R2-SB02-0-0.5, R4-SB03-0-0.5, R5-SB01-0-0.5, SPN-SB01-0-0.05, and SPN-SB01-0-0.05DUP. The MDLs were elevated because the sample extracts were diluted prior to instrumental analysis due to relatively high levels of nontarget background components.

Table 7. Comparison of Site-Wide Naturally Occurring Metal Concentrations and Background Concentrations

AOPC	Chemical	Max Concentration[(a)] (mg/kg)	Background Soil Concentration[(b)] (mg/kg)	U.S. EPA Residential PRG[(c)] (mg/kg)	HWRP Sediment Acceptance Criteria[(d)] (mg/kg)
Former Ordnance Magazines					
Building 193	Mercury	**0.48**	0.42	23 (nc)	0.43
Building 193	Silver	**4.81J**	0.21	390 (nc)	0.58
Perimeter Drainage Ditch					
Nickel		67	113.5	1600 (nc)	112
Thallium		**0.185**	ND	5.2 (nc)	ND
Revetments					
R1	Barium	**275**	189.9	5400 (nc)	ND
R2	Arsenic	*12.3*	16.7	0.062 (ca)	15.3
R2	Chromium (total)	**114**	107	210 (ca)	112
R2	Vanadium	*94.7J*	118	78 (nc)	ND
R3	Beryllium	**1.1J**	1.03	150 (nc)	ND
R3	Cobalt	**55.8**	27.6	900 (ca)	ND
R4	Antimony	**0.67J**	0.37	31 (nc)	ND
R4	Cadmium	**1.4**	0.64	37 (nc)	1.2
R4	Copper	**62**	48.8	3100 (nc)	68.1
R4	Lead	**234**	30.7	150 (nc)	43.2
Spoils Piles					
RSP	Selenium	**0.7J**	ND	390 (nc)	0.64
SPN	Zinc	**157J (110J)**	92	23000 (nc)	158

Shading indicates that the maximum concentration is below the background concentration. Chemicals with maximum concentrations below background are not included on Figure 7 that lists maximum concentrations detected because it is assumed that if concentrations are below background then the chemical is not related to previous site activities.

Italics numbers indicate that the maximum concentration was below background, but above the U.S. EPA Region 9 PRG.

J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

Bolding indicates concentrations exceeding background soil values, and identifies the metal for further evaluation in the human and ecological evaluations.

(a) Maximum concentration determined from both surface and subsurface samples. All maximum concentrations, except zinc, were associated with surface soil samples (i.e., 0-6 in bgs). However, because the ecological evaluation uses only the surface soil data (0-6 in bgs), the value in parentheses for zinc indicates the highest concentration for the surface soil.

(b) Background concentrations were represented by Army BRAC ambient soil data presented in the Final Human Health and Ecological Risk Assessment BRAC Property Hamilton Army Airfield (IT and CH2M Hill, 2001).

(c) U.S. EPA Region 9 PRGs, 2004

(d) RWQCB, 2005

HWRP - Hamilton Wetland Restoration Project

AOPC – area of potential concern

mg/kg – milligram per kilogram

ND - not determined.

nc – noncarcinogen; ca – carcinogen

R1 – Revetment 1

R2 – Revetment 2

R3 – Revetment 3

R4 – Revetment 4

RSP – Revetment Spoils Pile

SPN – Spoils Pile N

PRG – preliminary remediation goal

4.3.2 Data Validation. Following the examination by the laboratory, all of the sampling data were forwarded, along with the associated laboratory QC information, to an independent data validation contractor, Laboratory Data Consultants, Inc. (LDC) in accordance with the approved SAP (Battelle, 2005). Ninety percent of the results were subjected to a Contract Laboratory Program (CLP) Level-III data validation and 10% of the results were subjected to a CLP Level-IV validation (U.S. EPA, 1994, 1999). The data validation reports are included in Appendix D.

Data quality was assessed by verifying that the criteria defined in the SAP (Battelle, 2005) have been achieved for each compound class. Level-III data validation assumed that data values were correct as reported. Level-IV data validation included assessment of raw data packages, integration, interference assessment, and requantification (e.g., spectra and chromatograms) of reported QC values using the raw data. In addition, instrument performance, calibration and calibration standards were reviewed to ensure that the detection limits and data values were accurate and appropriate.

If initial calibration and/or continuing calibration criteria were not met for an analyte within a sample set, the sample results were flagged with "J" for detects and "UJ" for non-detects as noted in the validation reports.

If precision and/or accuracy criteria for MS/MSD or LCS/LCSD pairs were not met for an analyte within a sample set, then the sample results were flagged with "J" for detects and "UJ" for nondetects as noted in the validation reports.

If precision criteria (%RPD) for the field duplicates were not met for an analyte within a sample set, then the sample results were flagged with "J" for detects and "UJ" for nondetects as noted in the validation reports.

Data validation results are discussed by matrix below.

Groundwater Samples

- TPH-GRO: All data were accepted in the data validation.

- TPH-RRO: TPH-RRO was detected in one or more method blanks. If the sample result was less than five times the blank concentration, then the values were reported as nondetect at or above the (method reporting limit) MRL or MDL, depending on the original values.

- VOCs: All data were accepted in the data validation.

- SVOCs: Two analytes, diethylphthalate and di-n-butylphthalate were found in one or more method blanks. If the sample result was less than ten times, the blank concentration, then the values for diethylphthalate and di-n-butylphthalate were reported as nondetect at or above the MRL or MDL, depending on the original values.

- CAM 17 Metals: Several metals were detected in one or more method blanks. If the sample result was less than five times the blank concentration, then values for antimony (Sb), chromium (Cr), cobalt (Co), copper (Cu), nickel (Ni), silver (Ag), thallium (Tl), vanadium (Va) and/or zinc (Zn) were reported as nondetect at or above the MRL or MDL, depending on the original values.

- Explosives: All data were accepted in the data validation.

Soil Samples

- TPH-GRO: TPH-GRO was detected in one or more method blanks. If the sample result was less than five times the blank concentration, then the values were reported as nondetect at or above the MRL or MDL, depending on the original values.

- TPH-RRO: Residual range organics (TPH-RRO) were found in one or more method blanks. If the sample result was less than five times the blank concentration, then the values were reported as nondetect at or above the MRL or MDL, depending on the original values.

- VOCs: Two analytes, acetone and bromomethane, were found in one or more method blanks. Bromomethane was not detected in the soil samples. If the sample result for acetone was less than ten times the blank concentration, then the final concentration for acetone was reported at or above the MRL or MDL, depending on the original value.

- SVOCs: Several analytes, diethylphthalate, di-n-butylphthalate and *bis*(2-ehtylhexyl)phthalate were found in one or more method blanks. If the sample result was less than times the blank concentration, then the values were reported as nondetect at or above the MRL or MDL, depending on the original values.

- CAM 17 Metals: Several analytes were found in one or more method blanks. If the sample result was less than five times the blank concentration, then the values for Cd, Cu, Mercury (Hg), Ni, Ag, Tl, and/or Zn were reported as nondetect at or above the MRL or MDL, depending on the original values.

- Explosives: The analyte 2-nitrotoluene was found in one or more method blanks. If the sample result was less than five times the blank concentration, then the value for 2-nitrotoluene was reported as nondetect at or above the MRL or MDL, depending on the original value.

4.4 Comparison to Historical Data

Historical data for the SPN, the RSP, and area-wide Total DDT was provided in the Draft Background Summary Report (Battelle, 2004) and the Work Plan (Battelle, 2005). A full, in-depth data evaluation was not performed on the historical data as part of this PA/SI; however, a cursory review/comparison of the historical data and the data more recently collected for the PA/SI was conducted to determine whether all data (historical and PA/SI data) should be used in the human health screening-level and ecological risk evaluations. Results of the comparison are summarized below for the few areas where historical data exist.

RSP. Historical data for the RSP indicated the presence of metals and PAHs, but there was uncertainty associated with the analytical results due to matrix interference during the SVOC analysis. Results obtained during the PA/SI indicate the presence of some metals, but no PAHs. Concentrations of metals are consistent between sampling events for beryllium (1 mg/kg) and cadmium (1 mg/kg), but differ significantly for lead (230 mg/kg in 1995 vs. 12 mg/kg during the PA/SI) and copper (152 mg/kg in 1995 vs. 34 mg/kg in the PA/SI).

SPN. For SPN, the historical data identified lead and Total DDT as present within the footprint of the pile. Results obtained for the PA/SI sampling event also indicated the presence of lead and DDT. Historical concentrations of lead ranged from 16.5 mg/kg to 57.5 mg/kg, whereas the PA/SI lead results are somewhat lower, ranging from 5.4 mg/kg to 33.6 mg/kg. The historical Total DDT concentrations for SPN, which ranged from 0.0357 mg/kg to 0.088 mg/kg, are lower than the PA/SI results which range from 0.0003 mg/kg to 0.15 mg/kg. Total DDT concentrations for SPN are listed on Table 8.

Area-Wide Total DDT. Comparison of concentrations of area-wide Total DDT from the Army BRAC investigation (Figure 4) and the Total DDT concentrations obtained from the PA/SI are provided in Table 8. Total DDT concentrations from samples collected from the Ballfields Parcels during the Army BRAC investigation range from 0.0008 mg/kg to 0.0651 mg/kg. Total DDT concentrations obtained site-wide from the PA/SI are higher and range from 0.0002 mg/kg to 0.3583 mg/kg. Based on a review and comparison of the historical data (from the RSP, SPN, and area-wide Total DDT investigation) to the most recent data collected from these AOPCs during the PA/SI, it was decided that the screening evaluation would be conducted using both data sets so as to have the most robust dataset possible.

4.5 Conceptual Site Model

A conceptual site model (CSM) is presented here as Figure 9. The flowchart shows the potential sources of hazardous substances present in the AOPCs at the Ballfields Parcels, release mechanisms, and pathways that could result in exposures to human or ecological receptors. Air, groundwater, soils, surface water, and sediments pathways are incorporated into the CSM to show which exposure routes may be potentially significant for human or ecological receptors based on current and hypothetical site conditions. This specific CSM summarizes the receptors and pathways that are considered significant at the site under current and hypothetical conditions and is generally consistent with the version that was reviewed and approved by the regulatory agencies for the Work Plan (Battelle, 2005). The hypothetical resident receptor has been added to the CSM as a means to compare differences in exposure pathways between the more realistic site visitor receptor and the hypothetical resident receptor. Potentially complete significant pathways for the various receptors are denoted by black circles, whereas the white circles denote potentially complete insignificant pathways. Blank cells denote pathways that are not complete.

Table 8. Total DDT in Soil Concentrations on Navy Ballfields Parcels

Sampling Event	Sample ID/Location	Total DDT(a) (mg/kg)	Summary Statistics
PA/SI (April 2005)(b)	193-SB03-0-0.5	0.0306	Maximum = 0.3583 mg/kg Minimum = 0.0002 mg/kg
	PDD-SB01-0-0.5	0.2103	
	PDD-SB02-0-0.5	0.0371	
	PDD-SB03-0-0.5	0.1375	
	PDD-SB04-0-0.5	0.3583	
	PDD-SB05-0-0.5	0.0312	
	RSP-SB01-0-0.5 (R2-SB01)	0.0008	
	RSP-SB01-0-0.5 (DUP) (R2-SB01 DUP)	0.0004	
	RSP-SB01-1-2	0.0002	
	RSP-SB02-0-0.5	0.0005	
	RSP-SB02-5-6	ND	
	RSP-SB03-5-6	ND	
	RSP-SB03-0-0.5	0.0014	
	SPN-SB01-0-0.5	0.1184	
	SPN-SB01-0-0.5 (DUP)	0.1494	
	SPN-SB01-3-4	0.0009	
	SPN-SB02-0-0.5	0.009	
	SPN-SB02-4-5	0.0004	
	SPN-SB03-0-0.5	0.0054	
	SPN-SB03-4-5	0.0003	
Army BRAC Total DDT Investigation (March 2003)(c)	SO-86 (0-2 inches bgs)	0.0184	Maximum = 0.0651 mg/kg Minimum = 0.0008 mg/kg
	SO-86 (6-8 inches bgs)	0.0112	
	SO-86 (14-16 inches bgs)	0.004	
	SO-86 (22-24 inches bgs)	0.0008	
	SO-87 (0-2 inches bgs)	0.0651	
	SO-87 (6-8 inches bgs)	0.0075	
	SO-87 (14-16 inches bgs)	0.001	
	SO-87 (22-24 inches bgs)	0.001	
	SO-88 (0-2 inches bgs)	0.0398	
	SO-88 (6-8 inches bgs)	0.0103	
	SO-88 (14-16 inches bgs)	0.0033	

193 – Building 193
ND – not detected above the method detection limit
PA/SI – Preliminary Assessment/Site Inspection
PDD – Perimeter Drainage Ditch
RSP – Revetment Spoils Pile
(a) Total DDT is reported as the sum of 4,4′-DDT, 4,4′-DDD and 4,4′-DDE.
(b) Analytical data from the PA/SI investigation summarized in Appendix C.
(c) See Figure 4 for sampling locations.

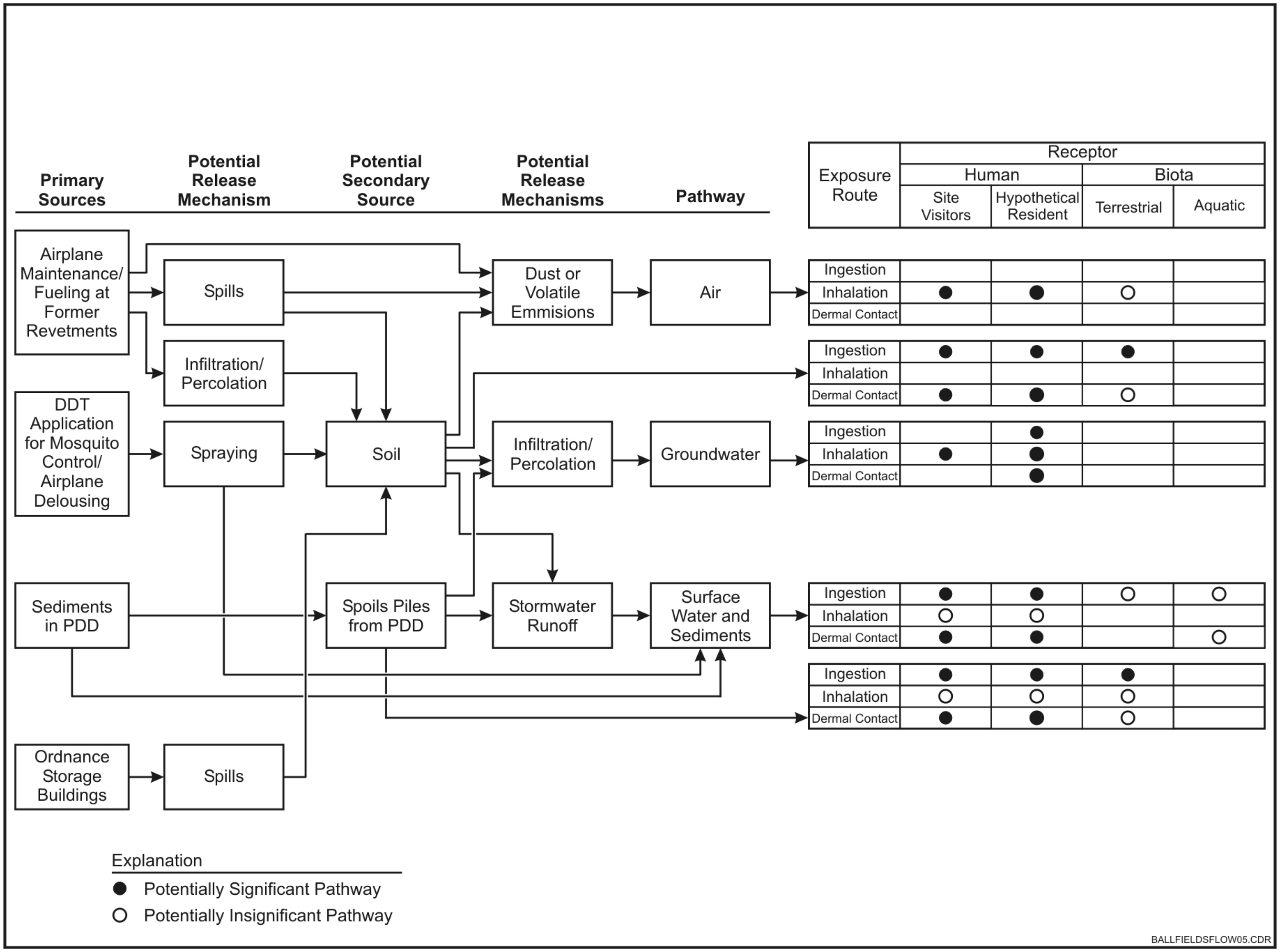

Figure 9. Conceptual Site Model

Section 5.0: HUMAN HEALTH SCREENING EVALUATION

A screening-level risk evaluation was performed to assess the potential for adverse effects resulting from human exposure to chemicals in soil and groundwater at the Ballfields Parcels. The results of the screening-level evaluation will be used to assist risk management decisions regarding the need for additional site characterization, risk assessment, remediation, or recommendation of no further action (NFA). The screening-level evaluation follows guidance provided in the DTSC PEA (1994) and associated DTSC (1994) Policy Memorandum based on an unrestricted hypothetical residential land-use scenario. The use of the residential land-use scenario offers a conservative approach for evaluating the Ballfields Parcels because the site is currently not used for residential housing, nor do future plans include residential housing. The Ballfields Parcels are currently comprised of open-spaced land, some of which is used for recreational purposes, whereas proposed future plans for the Ballfields Parcels entail restoration of this land to a seasonal wetland area, with a public access trail located along the western hillside of the property. However, as stated in the DTSC Policy Memorandum (1994), the use of an unrestricted scenario provides the greatest potential exposures to contaminants; thus, sites having acceptable risk for unrestricted land use also will have acceptable risk for other uses. A screening evaluation was conducted on a site-wide basis, by combining all of the data collected from each of the AOPCs and comparing the maximum concentrations detected across the site to conservative, risk-based screening values (see Section 5.3).

5.1 Identification of Chemicals of Potential Concern

Soil samples were only collected from 0-6 inches bgs and 2-6 ft bgs. Thus, for soil, a chemical of potential concern (COPC) was identified as any chemical detected in surface (0-6 inches bgs) and subsurface samples (2-6 ft bgs), except for naturally occurring inorganics present at levels at or below site background (Table 7) and organic or inorganic chemicals associated with laboratory or field blank contamination (see Sections 4.2.1 and 4.3). In accordance with the DTSC (1994) Policy Memorandum, inorganic chemicals present at levels above the PRGs, but at or below background may be eliminated from the screening procedure. Therefore, background comparisons were made in accordance with *Selecting Inorganic Constituents as Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities* (Cal-EPA, 1997).

For groundwater, a COPC was identified as any chemical detected, except for those chemicals associated with laboratory or field blank contamination. For chemicals that were not detected, the MDLs were compared to the risk-based screening levels, and the chemical was identified as a COPC if the MDLs were consistently higher than risk-based screening levels and if other associated chemicals that were detected supported the presence of this particular chemical in the environment.

Note on Table 7 that maximum concentrations of arsenic and vanadium are in bold italics to indicate these values are below background but above the U.S. EPA Region 9 PRG. Because these two naturally occurring chemicals were detected at concentrations below background, they were not identified as COPCs. Tables 4 and 5 identify the chemicals detected in soil and groundwater, respectively. Except for arsenic and vanadium in soil, all other chemicals detected in soil and groundwater were selected as COPCs.

Chemical groups such as TPH-GRO, TPH-DRO, and TPH-RRO were not considered in the COPC selection process because the major toxic components (i.e., benzene, toluene, ethylbenzene, PAHs, etc.) were analyzed for individually and included in the COPC selection process.

In order to be consistent throughout the report and with previous investigations, the pesticides, 4,4′-DDD, 4,4′-DDE, and 4,4′-DDT were summed together to provide Total DDT concentrations which were used in the screening evaluation.

5.2 Conceptual Site Model

The site-specific CSM, as presented in Figure 9, shows the primary sources and potential release mechanisms that have been identified for the Ballfields Parcels. Primary sources of hazardous materials that are included in the CSM are the former ordnance magazines, the PDD as it relates to the historical DDT applications, the former airplane revetments, and historical PDD sediment disposal resulting in the RSP and SPN. Air, groundwater, and soil pathways are incorporated into the CSM to show which exposure routes might be complete for the site recreational visitor.

For the most part, the site recreational visitor would be primarily exposed to chemicals in soil via inhalation of ambient air, incidental ingestion, and dermal contact. Exposure to chemicals in groundwater would only be likely via inhalation for VOCs present in the groundwater. Groundwater at the site is not appropriate for domestic use due to its high TDS and its very low recharge rate, and the City of Novato currently supplies drinking water to the site. Exposure to surface water and sediment would be likely via all three exposure routes (inhalation, ingestion, and dermal contact) if these environmental media had been identified as a concern. The PDD is the only area at the site having a potential surface water feature. Based on discussions with the regulatory agencies involved with the PA/SI, an agreed consensus was formed that evaluation of the PDD (other than the top of the banks), and any potential human and ecological receptors therein, did not need to be evaluated. The main reasons the PDD itself is not considered an AOPC are because: (1) the majority of the water flow comes from a permitted stormwater discharge facility operated by the City of Novato, and (2) all sediments and vegetation were removed to the concrete lining in 1998. Any impacts to the PDD resulting from historical site activities were addressed by the 1998 removal action and no additional evaluation is necessary.

However, as a conservative measure to assist in making risk management decisions for the Ballfields Parcels, a hypothetical residential scenario, rather than the actual receptor and exposure routes identified on the CSM, is used to evaluate the risks associated with exposure to chemicals in soil and groundwater. It is important to note that the property currently is not used for residential housing, nor will it be used for residential housing in the future. In fact, future development of the Ballfields Parcels is slated for seasonal wetlands reuse in accordance with the *Hamilton Army Airfield Final Reuse Plan* (Hamilton Local Reuse Authority, 1996), thus the most appropriate current and future receptor for the site is a recreational one.

The most likely routes of exposure to chemicals in soil for the hypothetical resident would be via direct contact (i.e., inhalation, incidental ingestion, and dermal contact) similar in nature to the site recreational visitor, but differing primarily for the exposure frequency (i.e., the number of days per year the individual comes into contact with the soil) and duration of exposure (i.e., the number of years the receptor is at the site). The exposure frequency and exposure duration are much greater for the resident compared to the site recreational visitor. Unlike the site recreational visitor who is expected to only come in contact with chemicals volatilizing from groundwater, exposure to chemicals in groundwater for the hypothetical residential receptor is conservatively based on the assumption that groundwater beneath the site is used for potable purposes, even though this groundwater is not appropriate for domestic use due to its high TDS, very low recharge rate, decreasing saturated aquifer thickness, and the lack of an adequate confining layer for sanitary well seals.

The screening-level risk evaluation conducted as part of this PA/SI report conservatively assesses a hypothetical residential exposure to chemicals in soil and groundwater using U.S. EPA Region

9 residential PRGs for soil and groundwater. The PRGs are derived taking into account the primary exposure routes for direct contact to soil and groundwater based on a residential exposure scenario. Thus, exposure routes identified for the hypothetical residential receptor at the site include those used to derive the PRGs, which are as follows:

- For soil – inhalation of particulates, inhalation of volatiles, incidental ingestion, and dermal absorption;
- For groundwater – ingestion from drinking and inhalation of volatiles.

Although exposure via inhalation of ambient air is a minor contributor to risk in most instances compared to ingestion and dermal contact, incorporation of all three exposure routes contributes to the conservative nature of this screening evaluation. One pathway of exposure not included in the derivation of the PRGs is inhalation of volatiles accumulating indoors. This exposure may be possible under a residential scenario, although considered to be an insignificant contributor to risk/hazard at the Ballfields Parcels, considering the low concentrations of volatile chemicals detected in the soil and groundwater at the site. Therefore, indoor air risk was evaluated separately using the Johnson and Ettinger model worksheet and added to the cumulative risk for the site.

5.3 Screening Process

For soil and groundwater, the risk-based screening values were U.S. EPA Region 9 PRGs for residential soil and tap water, respectively (U.S. EPA, 2004). These PRGs are risk-based concentrations that correspond to either a 1×10^{-6} cancer risk or a noncarcinogenic hazard quotient (HQ) of one. Soil PRGs are developed using default, conservative exposure assumptions for an integrated child/adult residential receptor based on exposure through ingestion, dermal contact, and inhalation of vapors and fugitive dust from soil. Groundwater PRGs are developed for residential exposure via ingestion and inhalation (as applicable) during showering, laundering, and dish washing. Inhalation of volatile chemicals from water was considered only for chemicals with a Henry's Law constant of 1×10^{-5} atm-m^3/mole or greater and with a molecular weight of less than 200 g/mole. Where available, "Cal-Modified" PRGs were used in the screening process in place of the U.S. EPA Region 9 PRG.

For COPCs without PRGs, chemical surrogates provided by DTSC were used to estimate potential human health risk from exposure to these chemicals. Table 9 summarizes the chemical surrogates and the rationale DTSC used to select them.

For PCBs, the procedures in *Cancer-Dose Response Assessment and Application to Environmental Mixture* (U.S. EPA, 1996) and *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures* (U.S. EPA, 2000) were followed to derive the total PCB risk. In addition, the 1997 World Health Organization toxic equivalent factor (TEF) scheme (Van den Berg et al., 1998) for each dioxin-like PCB congener was adopted. For dioxin-like and non-dioxin-like PCBs, residential soil PRGs for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and Aroclor 1254 were used in the screening evaluation (3.9×10^{-6} mg/kg and 0.22 mg/kg, respectively). Details regarding the toxic equivalent concentrations for dioxin-like and nondioxin-like PCB congeners and PCB risk are provided in Attachment F.1 of Appendix F.

For each COPC, risk ratios were derived by dividing the maximum concentration detected by the corresponding PRG. For carcinogenic compounds, risk ratios were multiplied by 10^{-6} to estimate the cancer risk and then summed across COPCs and environmental media to provide an estimate of total risk. Similarly, risk ratios for noncarcinogenic COPCs were used as an estimate of the HQ and subsequently summed together and across media to estimate the hazard index (HI).

Table 9. Chemical Surrogates for the HHRA Provided by DTSC

COPC	Chemical Surrogate	U.S. EPA Region 9 Soil PRG (mg/kg)	U.S. EPA Region 9 Tap Water PRG (µg/L)	Rationale
2-Methylnaphthalene	Naphthalene	1.7	0.093	– structural similarity
Acenaphthylene	Acenaphthene	3,700	370	– structural similarity – non-carcinogen
Acetophenone	Benzaldehyde	6,100	3,600	– structural similarity – same oral reference dose
Benzo(g,h,i)perylene	Pyrene	2,300	180	– relative location of aromatic rings – non-carcinogen
Phenanthrene	Anthracene	22,000	1,800	– structural similarity – non-carcinogen
4-Chloro-3-methylphenol	2-Chlorophenol	63	30	– similar route of exposure, and metabolism – bioaccumulation

The screening process for lead is conducted a little differently because of the way lead exposure is evaluated (i.e., through blood lead levels, rather than by adverse toxic effects). Therefore, maximum concentrations of lead are compared directly to the PRGs provided by U.S. EPA Region 9, rather than deriving risk ratios and estimates of the HQ to determine whether concentrations may be associated with unsafe levels.

For vapor intrusion to indoor air, risk and hazard for VOCs in groundwater were estimated using the DTSC-modified Johnson and Ettinger spreadsheet, whereas the risk and hazard for VOCs in soil were estimated using U.S. EPA's Johnson and Ettinger spreadsheet modified to account for DTSC-specific toxicity values for naphthalene, methylene chloride, benzo(b)fluoranthene, and chrysene (note DTSC does not provide a soil to indoor air modified Johnson and Ettinger spreadsheet). A slab on grade building was assumed in conjunction with spreadsheet default settings. VOCs evaluated for vapor intrusion included all compounds detected in soil and groundwater that are listed in DTSC's *Guidance for The Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (2005). Sample calculation spreadsheets have been provided in Attachment F.2 of this report for one COPC in soil and one COPC in groundwater for the indoor air risk estimations to identify input parameters. A table summarizing all indoor air estimates for each COPC in soil and groundwater also has been provided in Attachment F.2.

Only two chemicals, 2-nitrotoluene and 1,2-dibromoethane, were nondetect in groundwater but had MDLs consistently greater than the U.S. EPA Region 9 PRG. Neither of these chemicals were detected in soil (soil MDLs were lower than Region 9 PRGs); thus they were considered as nondetect for groundwater and were not selected as COPCs for evaluation in the human health screening-level evaluation.

Results of the soil and groundwater COPC screenings are provided in Appendix F. The screening tables in Appendix F provide the COPC, maximum concentration, PRGs, and chemical-specific risk ratios. The estimated total cancer risks for soil and groundwater pathways combined are summarized in Table 10, as are the estimated total HIs for soil and groundwater combined.

Table 10. Summary of Estimated Site-Wide Total Cancer Risks and Hazard Indices

Environmental Medium	Risk	HI
Soil [(a)]	1.6×10^{-6}	0.2
Soil to Indoor Air	3.7×10^{-6}	0.07
Groundwater [(b)]	1.3×10^{-2}	14.0
Groundwater to Indoor Air	2.4×10^{-7}	0.03
Total	$\mathbf{1.3 \times 10^{-2}}$	**14.2**

HI – hazard index

(a) Exposure to soil includes ingestion, inhalation of particulates, inhalation of volatiles in ambient air, and dermal absorption.

(b) Exposure to groundwater includes ingestion inhalation of volatiles in ambient air.

5.4 Risk Characterization

The U.S. EPA target risk 1×10^{-6} for cancer risk and 1.0 for the noncancer HI (U.S. EPA, 1991) are used to evaluate the relative magnitude of risk and hazard estimated from the screening evaluation. Combined soil and groundwater cancer risk and HI estimates are provided in Table 10.

5.4.1 Risk/Hazard Estimates for Soil. For soil (Table 10), the site-wide estimated total cancer risk for soil is 1.6×10^{-6}, just slightly above U.S. EPA's target risk of 1×10^{-6}. COPCs primarily contributing to the excess risk include chromium (5.4×10^{-7}), Total PCBs (3.2×10^{-7}), and benzo(a)pyrene (2.6×10^{-7}). Maximum concentrations of each of these COPCs contributing to the excess risk were obtained from three different areas of the property (Revetment 2, Building 193, and Revetment 4, respectively) (see Appendix F for chemical-specific calculations). Note that the conservative nature of the screening-level risk assessment assumes that the hypothetical residential receptor will come into contact with the maximum chemical concentrations in soil, regardless of where these concentrations are located with respect to one another, every day throughout the entire exposure duration. As can be seen on Figure 7, all three of these maximum concentration locations (Revetment 2, Building 193, and Revetment 4) are fairly spread out, which makes it difficult to imagine anyone coming into contact with maximum chemical concentrations every day for any extended period of time. As shown on Table 10, the estimated total site-wide HI is below 1.0.

Lead was evaluated by comparing concentrations detected to the residential U.S. EPA Region 9 PRG. U.S. EPA Region 9 provides two PRGs for comparing lead concentrations: a California-modified PRG of 150 mg/kg, which is derived based on California EPA's pharmacokinetic model, LeadSpread, run in the reverse; and another PRG of 400 mg/kg, derived using U.S. EPA's Integrated Exposure, Uptake and Biokinetic model run in reverse. All lead concentrations, except for the maximum concentration of 234 mg/kg (detected in Revetment 4), were less than the more conservative PRG of 150 mg/kg. However, the maximum concentration of 234 mg/kg is well below the U.S. EPA lead PRG of 400 mg/kg.

5.4.2 Risk/Hazard Estimates for Groundwater. For groundwater (Table 10), the total site-wide cancer risk estimate is 1.3×10^{-2}. Arsenic was the primary COPC contributing to the excess risk (1.25×10^{-2}), whereas *bis*(2-ethylhexyl)phthalate in groundwater at Revetment 1 also contributed slightly to the excess risk (3.1×10^{-6}). As shown on Table 10, the estimated site-wide HI of 14.0 was above the U.S. EPA criterion of 1.0. Vanadium is the primary COPC contributing to the excess hazard and is associated with an HQ greater than 1.0 (Appendix F). Additional inorganic COPCs that are not associated with an HQ greater than 1.0, but which add to the site-wide HI include barium, cadmium, nickel, and thallium (Appendix F).

It is important to note that the estimates of cancer risk and noncancer HIs are the result of the hypothetical residential receptor using the groundwater beneath the site as drinking water. Ingestion of metals in groundwater is the primary reason for the elevated risk/hazard estimates. As stated previously in the report, groundwater beneath the Ballfields Parcels is not suitable for use as drinking water because of the high TDS, very low recharge rate, decreasing saturated aquifer thickness, and the lack of an adequate confining layer for sanitary well seals. Based on these site characteristics, Marin County permitting requirements for installation of groundwater production wells for any use would not be met. As such, even if a residential housing development were to be constructed on the Ballfields Parcels, groundwater beneath the property could not be used for consumption and the residents would be supplied water from the City of Novato which is the current source of drinking water at the site. In addition, the low yield and high salinity of groundwater present at the Ballfields Parcels precludes its use for any other beneficial purposes including, agriculture, irrigation, and industrial use. Therefore, the only viable exposure route of concern for either the hypothetical resident or the more applicable site recreational visitor is inhalation of chemicals that volatilize from groundwater. Risks/hazards for inhalation of ambient air cannot be identified using the risk ratio comparison, but note that the more conservative risk/hazard estimates for vapor intrusion to indoor air from VOCs in groundwater do not exceed the cancer risk criterion of 1.0×10^{-6} or noncancer hazard criterion of 1.0 (Table 10 and Table F.2-1 in Attachment F.2). Thus, because groundwater will not be used for drinking water, or for any other beneficial purposes, the estimates of groundwater risks/hazards presented here overestimate the actual risks associated with the hypothetical resident and recreational visitor at the site.

5.5 Uncertainty Associated with Human Health Evaluation

A qualitative evaluation is provided in this section to address additional uncertainties associated with the estimates of risk/hazard that have not previously been presented in this report. Because a standard residential land use scenario was assumed for the site screening, this uncertainty analysis does not consider the uncertainty related to the use of residential default exposure parameters. Rather, the analysis focuses on the specific site conditions and lack of screening values which contribute to the uncertainty.

- One source of uncertainty is the use of maximum concentrations for site screening. The use of maximum concentrations to estimate risk is more conservative than using an arithmetic average. Also, the sampling strategy for the Novato Ballfields was geared towards collecting samples from AOPCs with the highest potential contaminant concentrations, which adds even more conservatism to the use of maximum concentrations. Thus, risks associated with soil and groundwater are more likely to be overestimated.

- The groundwater samples collected from the site appear to contain high concentrations of metals. These high concentrations may be associated with the presence of suspended particles, or may be due to the methodology used to collect these samples. The groundwater sampling conducted at the Ballfields Parcels was accomplished using open boreholes and temporary slotted PVC screen. Field personnel observed suspended solids in the groundwater samples, and given that background levels of arsenic are known to exist in soils, it is reasonable to measure arsenic in the unfiltered, turbid groundwater samples. As discussed in Section 4.3, the results for sample R3-GW01-DUP were significantly different from those of parent sample R3-GW01, and inspection of the sample bottles showed that R3-GW01 was visibly different from the duplicate sample and contained more particulate material. As a result, groundwater concentrations do not accurately reflect concentrations that would be in drinking water and therefore the risks/hazards are likely to be overestimated.

- Another source of uncertainty is the assumption that groundwater will be used for domestic purposes (e.g., drinking). As described in Sections 2.3 and 5.4.2, groundwater beneath the property is unsuitable for beneficial uses, including domestic, agricultural, and industrial. Thus, the risks/hazards associated with ingestion of metals in groundwater are overestimated.

- Several of the COPCs selected for soil (2-methylnaphthalene, acenaphthylene, acetophenone, benzo(g,h,i)perylene, and phenanthrene) do not have U.S. EPA Region 9 PRGs. Therefore, PRGs of chemical surrogates were used to estimate risk and hazard. Chemical surrogates were recommended by DTSC based on structural similarities and/or toxicity properties. 2-Methylnaphthalene was the only COPC evaluated as a carcinogen based on its structural similarity to naphthalene. Based on U.S. EPA's weight-of-evidence characterization, naphthalene is designated as a possible human carcinogen, whereas data for 2-methylnaphthalene are inadequate to assess human carcinogenic potential; thus, the total carcinogenic risk estimates that include 2-methylnaphthalene may be overestimated. For acetophenone, the hazard estimates based on the PRG for its surrogate compound, benzaldehyde, are similar to what would be expected for acetophenone, given that these two compounds are structurally similar and have the same oral reference dose (1×10^{-1} mg/kg day). For the other three COPCs evaluated using noncarcinogenic surrogate compounds, the estimated hazard may be over- or underestimated depending on the specific toxicity characteristics of these compounds.

- Several of the COPCs selected for groundwater (2-methylnaphthalene, 4-chloro-3-methylphenol, acetophenone, and phenanthrene) do not have U.S. EPA Region 9 PRGs. Estimates of risk/hazard for these compounds were instead based on PRGs of surrogate compounds recommended by DTSC. 2-methylnaphthalene was the only COPC evaluated as a carcinogen based on its structural similarity to naphthalene. Based on U.S. EPA's weight-of-evidence characterization, naphthalene is designated as a possible human carcinogen, whereas data for 2-methylnaphthalene are inadequate to assess human carcinogenic potential; thus, the total carcinogenic risk estimates that include 2-methylnaphthalene may be overestimated. For acetophenone, the hazard estimates based on the PRG for its surrogate compound, benzaldehyde, are similar to what would be expected for acetophenone, given that these two compounds are structurally similar and have the same oral reference dose (1×10^{-1} mg/kg day). For the other two COPCs evaluated using noncarcinogenic surrogate compounds, the estimated hazard may be over- or underestimated depending on the specific toxicity characteristics of these compounds.

- Lead is listed as a carcinogen and as a reproductive and developmental toxic chemical under the Safe Drinking Water and Toxic Enforcement Act of 1986, "Proposition 65" (California Health and Safety Code, Chapter 6.6, section 25249.5 et seq.) The Public Health Goal (PHG) adopted by California EPA for lead in drinking water is 2 μg/L, which is based on noncarcinogenic effects. California EPA also derived a PHG for lead of 6 μg/L for carcinogenic effects. A PHG is a concentration in drinking water that poses no significant health risk if consumed for a lifetime, based on current risk assessment principles, practices, and methods. For lead, concentrations in groundwater ranged from

4 µg/L to 424 µg/L at the seven of the Ballfields Parcels AOPCs (R1 through R5, RSP, and SPN). Concentrations in all seven samples exceed the adopted noncarcinogenic PHG of 2 µg/L, and six of the seven lead concentrations exceed the carcinogenic PHG of 6 µg/L. Therefore, estimates of cancer risk and noncancer hazard have been underestimated in these seven AOPCs, assuming groundwater will be used for domestic purposes, which is not likely.

- Soil-gas data are preferred over soil data for modeling vapor intrusion; however, all vapor intrusion modeling was done based on soil and groundwater data. This introduces a large amount of uncertainty in the risk results.

Section 6.0: ECOLOGICAL RISK EVALUATION

An ecological risk assessment was conducted using data collected from the Ballfields Parcels during the PA/SI to evaluate the potential for adverse effects to ecological receptors resulting from exposure to contaminants in surface soil (0-6 inches bgs) under current conditions (Battelle, 2005). This evaluation is consistent with multiple guidance manuals including *Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities* (DTSC, 1996); *Framework for Ecological Risk Assessment* (U.S. EPA, 1992); *Ecological Risk Assessment Guidance for Superfund* (U.S. EPA, 1997); and *Guidance for Conducting Ecological Risk Assessments* (U.S. Navy, 2001). DTSC is the lead regulatory agency with respect to risk assessment for the Navy's Ballfields Parcels; therefore, the ecological risk assessment approach closely followed DTSC and Navy guidance as documented in the Final SAP (Battelle, 2005). The overall objectives of the ecological risk assessment for the Ballfields Parcels were to:

1. Evaluate potential risks associated with exposure to COPECs detected in soil samples from the Ballfields Parcels using data that were collected during recent sampling activities;
2. Determine if further assessments are warranted and, if so, identify any additional data needs to support the assessments; and,
3. Conduct additional ecological assessments, as required.

A phased approach was followed for the ecological risk assessment at the Ballfields Parcels. The first phase, which was conducted as part of the Work Plan (Battelle, 2005), consisted of the scoping-level ecological risk assessment (SLERA), which included the development of a CSM, identification of COPECs, receptors of concern (ROCs), and potential exposure pathways. As depicted in the CSM (see Figure 9), the results of the SLERA indicated that ecological receptors may be directly or indirectly exposed to contaminants present at the site. Therefore, a Phase I predictive assessment was conducted using data from the April 2005 PA/SI sampling event and results from the SLERA. Conservative exposure assumptions were made for ROCs and COPECs in the Phase I predictive assessment to estimate risk to biota at the site. The results of the Phase I predictive assessment are presented in this report.

6.1 Scoping-Level Ecological Risk Assessment

The objectives of the SLERA, under DTSC guidance, are to develop a CSM and to identify COPECs, ROCs, and potential exposure pathways (DTSC, 1996). For the purpose of this investigation, the SLERA was conducted as part of the Work Plan (Battelle, 2005). In that process, a CSM was developed for the Ballfields Parcels (see Figure 9) which identifies the receptors at risk, the exposure media, and the completed exposure pathways present at the Ballfields Parcels. The following subsections provide a summary of the biological evaluation and applicable exposure pathways that exist at the Ballfields Parcels. The results of the SLERA were used in the Phase I predictive assessment to estimate the risk of contaminant exposure to ROCs at the Ballfields Parcels.

6.1.1 Biological Evaluation. The 18.37 acres comprising the Navy Ballfields Parcels is characterized as a terrestrial, grassland habitat with some developed areas (JSA, 1998a). Annual grassland provides important habitat for wildlife; however, because this land is fragmented by old service roads and the entire property encompasses a relatively small area, the quality of wildlife habitat is considered moderate (IT and CH2MHill, 2001). The Ballfields Parcels are located approximately 4,530 ft west of San Pablo Bay, and lie within the 100-year floodplain. Therefore, this area is not tidally influenced and is characterized by upland flora and fauna. The grassland provides foraging habitat for a variety of animals, including deer, rodents, raptors, snakes, lizards, and songbirds. Ecological surveys have been conducted in the grasslands on bats (LSA, 1997a) and the burrowing owl (LSA, 1997b).

Plant Community. Common species of non-woody plants have been considered representative of the HAAF because they are important as primary producers and as prey sources to herbivorous animals. The Ballfields Parcels are dominated by blackberry bushes, although other weedy upland plants also grow in the area. These include yellow star thistle, wild radish, wild oat, black mustard, as well as grasses such as barley, ryegrass, and tall fescue (IT and CH2MHill, 2001). In addition, vegetation growing in and along the PDD include cattails. The vegetation on the Ballfields Parcels provides habitat to terrestrial animal species.

Invertebrate Community. The invertebrate community on the Ballfields Parcels is expected to be typical of similar grassland, and terrestrial environments and consists of earthworms and various insects. These invertebrates play a variety of important roles in ecosystems. Their feeding and burrowing activities can enhance decomposition and nutrient cycling. Earthworm burrows can enhance water infiltration and gas exchange. In addition, invertebrates serve the dietary needs of upper trophic species of birds and other omnivorous animals.

Avian Community. A variety of bird species have been observed on the Ballfields Parcels. These include scrub jays, swallows, meadowlarks, harriers, red-tailed hawks, sparrows, California quail, red-necked pheasant, turkey vulture, and American robins (Jolliffe, personal communication, 2004). Some bird species inhabit the property year-round, whereas others are migratory and make transient visits to the area for foraging or nesting.

Mammal Community. The Ballfields Parcels provide foraging and nesting habitats for several terrestrial species of mammals: coyote, striped skunk, desert cottontail, and black-tailed jack rabbit. The black-tailed deer (*Odocoileus hemionus*) is a large mammalian herbivore that is also known to occur at HAAF, feeding on nonwoody plants within the Ballfields Parcels. The California vole (*Microtus californicus*) is a small rodent that is abundant in dense annual grasslands, such as the Ballfields Parcels. It feeds on grasses, sedges, and herbs, and provides prey for upper-trophic-level predators such as hawks, owls, and snakes. Finally, the raccoon (*Procyon lotor*) is a medium-sized omnivorous mammal that is an inhabitant of the Ballfields Parcels and other grassland areas where it often builds its home in the abandoned dens of other animals.

Special Status Species. Based on biological surveys conducted by the Army BRAC Program and the CCC on the former HAAF property, there are no threatened or endangered species or habitats located in the area (Jolliffe, personal communication, 2004). The salt-marsh harvest mouse (*Reithrodontomys raviventris*) is listed as a federally endangered species by the U.S. Fish and Wildlife Service and inhabits the San Francisco, San Pablo, and Suisun bays. Salt marsh harvest mice are critically dependent on dense cover and their preferred habitat is pickleweed, a common salt-marsh plant (*Salicornia virginica).* Due to the lack of pickleweed within the Ballfields Parcels, these animals are not expected to inhabit the area. However, several species of special concern, as designated by the State of California are believed to be present. These include the northern harrier (*Circus cyaneus*) and the burrowing owl (*Speotyto cunicularia*). Given this special status designation, these two species in addition to others are proposed as ROCs and are discussed further in Section 6.1.5.

6.1.2 Exposure Pathways. The CSM is a framework for relating ecological receptors to contaminated media in order to identify and evaluate the significance of complete exposure pathways. In general, an exposure pathway describes the course a chemical takes from the source to the environmental media and then to the exposed receptor. An exposure pathway analysis links the source, location, and type of environmental release with population location and activity patterns to determine the primary pathways of exposure. If potentially complete and significant exposure pathways exist between contaminants and receptors, an assessment of potential effects and exposure is conducted. Only those potentially complete exposure pathways likely to contribute to the total exposure will be evaluated. An exposure pathway is considered complete and significant if all four of the following elements are present:

1. A source and mechanism of chemical release to the environment;
2. An environmental transport medium (e.g., soil) for the released chemical;
3. A point of potential physical contact of a receptor with the contaminated medium (exposure point); and,
4. An exposure route (e.g., ingestion of contaminated prey, incidental ingestion of soil).

Terrestrial wildlife may be exposed to chemical contaminants through three major pathways: ingestion, dermal contact, or inhalation. The most significant routes of exposure for higher trophic organisms at the site are associated with the ingestion of contaminated prey and direct or indirect incidental ingestion of soil (Figure 9). The contaminants potentially present on the Ballfields Parcels that are most likely to present a risk through inhalation exposure are VOCs, which rapidly volatilize from soil into the air where they are diluted and dispersed. Much of the Ballfields Parcels is vegetated; therefore, exposure of soil to wind is likely minimal and, consequently, aerial suspension of potentially contaminated dust particles is reduced. Although several VOCs were detected in soil samples, the concentrations were very low. As such, exposure via inhalation was assumed to be negligible; therefore, VOCs were not quantitatively evaluated in the ecological risk assessment.

Dermal exposure to soil contaminants for birds and mammals, although likely to occur, is also considered to be minimal. Although established methods are available to assess dermal exposure to humans, only limited data are available to quantitatively assess dermal exposure to wildlife. In addition, the presence of feathers and fur along with grooming and preening activities greatly reduces soil contact with skin (Sample and Suter, 1994).

Groundwater is not considered a significant pathway for contaminant transport at HAAF because of the extremely low hydraulic conductivity of the Bay Mud that underlies the site (IT and CH2MHill, 2001). However, standing water may occur periodically on the Ballfields Parcels and in the PDD as a result of severe storms, which has been observed by Navy and state personnel during a site walk that followed a record rainfall event that occurred on February 24, 2004. These pools are temporary and likely do not constitute a sustainable habitat for aquatic wildlife. Although exposure to contaminants from ingestion of sediments from the bottom of the PDD is considered minimal, inputs from upland erosion may be possible. Because of this, soil samples were collected along the banks of the PDD and analyzed for Total DDT compounds (DDD, DDE, and DDT) and metals. All sediments were removed down to the concrete lining of the PDD in 1998 (IT, 2000); therefore, it is unlikely that all of the sediment that has collected along the bottom of the PDD since 1998 is associated with historical military activities that ceased in 1974. Rather, the majority of sediment present in the PDD today is most likely associated with the City of Novato permitted storm water discharge outfall.

A review of major exposure pathways indicates that there are potentially complete exposure pathways to terrestrial plants and avian receptors, such as the American robin, burrowing owl, and northern harrier. Exposure pathways for mammals, such as the California vole and raccoon, also appear to be complete. The rationale for selecting the receptors of concern is provided in Section 6.1.5.

6.1.3 Assessment Endpoints. Based on the ecological resources and complete exposure pathways identified in the CSM, assessment endpoints (AEs) were developed to identify the ecological resources at the site that should be protected. In general, AE selection considers the ecosystem and species relevant to a specific site. AEs are defined based on technical considerations, including:

- Chemicals present and their concentration;
- Mechanisms of toxicity of the chemicals to different groups of organisms;
- Ecologically relevant receptor groups that are potentially sensitive or highly exposed to the chemicals; and,
- Potentially complete exposure pathways.

The AEs selected to represent the resources to be protected at the Ballfields Parcels are:

1. Sufficient rates of survival, growth, and reproduction to sustain populations of mammals (represented by the California vole and raccoon) at the Ballfields Parcels.
2. Sufficient rates of survival, growth, and reproduction to sustain the avian population (represented by the robin) at the Ballfields Parcels.
3. Survival, growth, and reproduction of individuals of species of special concern at the Ballfields Parcels (represented by the northern harrier and burrowing owl).
4. Survival of terrestrial plant populations at the Ballfields Parcels.

6.1.4 COPEC Screening Process. A screening exercise was conducted to identify COPECs requiring further evaluation in the Phase I predictive assessment because potentially complete pathways exist for the AEs identified in Section 6.1.3. The screening exercise consisted of comparing maximum concentrations detected in surface soil to conservative soil screening benchmark values protective of plants, invertebrates, mammals, and/or birds. Soil screening benchmarks were obtained from U.S. EPA guidance and peer reviewed literature provided by Oak Ridge National Laboratory (ORNL). Screening levels obtained from U.S. EPA guidance documents were given preference over peer-reviewed documents in most cases because of the outside expert collaboration U.S. EPA included during the development of the screening levels and the rigid internal review processes U.S. EPA requires before releasing guidance. Thus, soil screening benchmarks were obtained according to the following hierarchy:

1. U.S. EPA Interim Soil Screening Levels (Eco-SSLs) (U.S. EPA, 2005);
2. U.S. EPA Region 5 Ecological Screening Levels (U.S. EPA, 2003);
3. ORNL peer-reviewed literature and guidance Toxicological Benchmarks (Efroymson et al., 1997a; Sample, et al., 1997).

The methodology used to derive the Eco-SSLs included food chain exposures where appropriate; thus, these numbers were designed to be protective of bioaccumulation hazards in wildlife. The Eco-SSLs provided screening levels for plants, invertebrates, birds, and/or mammals where data were available. The lowest of the Eco-SSL receptor-specific screening value was chosen as the screening benchmark in this evaluation. Similarly, the U.S. EPA Region 5 screening levels for soil were derived for plants, invertebrates, birds, and/or mammals and were designed to be protective of bioaccumulation hazards in wildlife where data were available. The lowest of the receptor-specific screening values was chosen by U.S. EPA Region 5 to represent their default screening value, which was selected as a soil screening benchmark in this screening exercise. In general, the ORNL toxicological benchmarks used in this screening assessment were derived based on toxicity to plants and invertebrates and were not designed to account for bioaccumulation hazards in wildlife. The exception to this is the benchmark used for Total PCBs. The benchmark selected for Total PCBs was obtained from Efroymson et al. (1997b). The PRG for Total PCBs was derived for three types of organisms (wildlife, plants, and soil invertebrates) and the lowest value available provided as the PRG. The wildlife PRG was designated as the PRG for Total PCBs and was derived by iteratively calculating exposure estimates using different soil concentrations and soil-to-biota contaminant uptake models. Table 11 summarizes the chemicals detected in surface soil and their associated soil screening benchmarks used for the soil screening. Chemicals identified as bioaccumulative compounds from the U.S. EPA Region 9 list of bioaccumulative substances (Hoffman, 1998) also are noted in Table 11.

All chemicals detected in soil samples collected from the Ballfields Parcels were examined using the following COPEC screening process:

1. The maximum concentration detected in surface soil from across the site (i.e., site-wide) was compared to the soil screening benchmark selected for that chemical.

2. Chemicals were excluded as COPECs if any of the following were true:

   - Maximum concentrations of naturally occurring chemicals were less than background concentrations (as indicated on Table 7);
   - Maximum concentrations of naturally occurring chemicals were greater than background concentrations, but less than the screening benchmark;
   - Maximum concentrations of organic compounds that are not bioaccumulative were less than the screening benchmark.

A detailed table that provides the screening of the chemicals is provided in Appendix G (Table G-1). Included on this screening table are the chemicals, their maximum concentrations, location of the maximum concentration, the screening benchmark and associated receptor group, and an indication of whether the chemical was retained as a COPEC.

A summary of the chemicals retained as COPECs is provided in Table 12. Thirty-three chemicals, including 11 metals, two explosives, Total PCBs, and SVOCs (including PAHs) were retained as COPECs. Four of the 33 chemicals were retained as COPECs because soil screening benchmarks were not available. Cobalt has been retained as a COPEC as indicated in Table 12; however, this COPEC will only be evaluated further as a concern for plants and not carried through a dose assessment for reasons provided in Table 12. Arsenic, nickel, and vanadium were not retained as COPECs because maximum concentrations were less than background concentrations. Many of the SVOCs and VOCs were not retained as COPECs because maximum concentrations were below the soil screening benchmark. Note that all PAHs were retained as COPECs for evaluation in the Phase I Predictive Assessment at the request of the Department of Fish and Game. Additional information regarding PAH assessment is provided in Section 6.2.

Three analytes, 2,4-dimethylphenol, 2,4-dinitrophenol, and 2-chloronaphthalene, were not detected in any of the soil samples collected from the Ballfields Parcels, but some of the sample MDLs for these three compounds were above the screening benchmarks of 0.01 mg/kg, 0.061 mg/kg, and 0.0122 mg/kg, respectively. Out of a total of 34 soil samples (including duplicate samples) collected from the Ballfields Parcels, the MDLs for 2,4-dimethylphenol, 2,4-dinitrophenol, and 2-chloro-naphthalene associated with seven of the samples exceeded the screening benchmarks. According to the analytical laboratory that analyzed the soil samples, the MDLs were elevated in these seven samples because sample extracts were diluted prior to instrumental analysis due to relatively high levels of

Table 11. Chemicals Detected in Surface Soil and Soil Screening Benchmarks

Chemical	Selected Soil Screening Benchmark (mg/kg)	Receptor Group	Source[a]
Explosives			
2,6-Dinitrotoluene	0.033	mammal	U.S. EPA Region 5
HMX	NA	mammal	NA
Metals			
Antimony	0.27	mammal	Eco-SSL
Arsenic[b]	18	plant	U.S. EPA Region 5
Barium	330	invert	Eco-SSL
Beryllium	21	mammal	Eco-SSL
Cadmium[b]	0.36	mammal	Eco-SSL
Chromium (total)[b]	0.4	invert	U.S. EPA Region 5
Cobalt	13	plant	Eco-SSL
Copper [b]	5.4	mammal	U.S. EPA, Region 5
Lead[b]	11	bird	Eco-SSL
Mercury [b]	0.1	invert	U.S. EPA Region 5
Nickel [b]	13.6	mammal	U.S. EPA Region 5
Selenium[b]	0.028	mammal	U.S. EPA Region 5
Silver[b]	4.04	mammal	U.S. EPA Region 5
Thallium	0.057	mammal	U.S. EPA Region 5
Vanadium	7.8	bird	Eco-SSL
Zinc[b]	6.62	invert	U.S. EPA Region 5
Semivolatile Organic Compounds			
2-Methylnaphthalene	3.24	mammal	U.S. EPA Region 5
2-Nitroaniline	74.1	mammal	U.S. EPA Region 5
Acenaphthylene	682	mammal	U.S. EPA Region 5
Acetophenone	300	mammal	U.S. EPA Region 5
Anthracene[b]	1480	mammal	U.S. EPA Region 5
Benzaldehyde	NA	mammal	NA
Benz(a)anthracene[b]	5.21	mammal	U.S. EPA Region 5
Benzo(a)pyrene [b]	1.52	mammal	U.S. EPA Region 5
Benzo(b)fluoranthene[b]	59.8	mammal	U.S. EPA Region 5
Benzo(g,h,i)perylene[b]	119	mammal	U.S. EPA Region 5
Benzo(k)fluoranthene[b]	148	mammal	U.S. EPA Region 5
Bis(2-ethylhexyl)phthalate	0.925	mammal	U.S. EPA Region 5
Butyl benzyl phthalate	0.239	mammal	U.S. EPA Region 5
Caprolactam	NA	mammal	NA
Carbazole	NA	mammal	NA
Chrysene[b]	4.73	mammal	U.S. EPA Region 5
Dibenz(a,h)anthracene[b]	18.4	mammal	U.S. EPA Region 5
Diethyl phthalate	24.8	mammal	U.S. EPA Region 5
Di-n-butyl phthalate	0.15	mammal	U.S. EPA Region 5
Fluoranthene[b]	122	mammal	U.S. EPA Region 5
Indeno(1,2,3,-c,d)pyrene[b]	109	mammal	U.S. EPA Region 5
Naphthalene	0.099	mammal	U.S. EPA Region 5
Phenanthrene[b]	23	mammal	U.S. EPA Region 5
Phenol	120	mammal	U.S. EPA Region 5
Pyrene[b]	78.5	mammal	U.S. EPA Region 5
Volatile Organic Compounds			
TPH	1000	invert	ORNL[c]
Acetone	2.5	mammal	U.S. EPA Region 5
Methylene chloride	4.05	mammal	U.S. EPA Region 5
m,p-Xylenes	10	plant	U.S. EPA Region 5
o-Xylenes	10	plant	U.S. EPA Region 5
Pesticides and PCBs			
Total DDT[b,e]	0.0035	mammal	U.S. EPA Region 5
Total PCBs[b]	0.371	mammal	ORNL Eco-PRG[d]

NA – not available
DDT – dichlorodiphenyltrichloroethane
HMX - 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane
(a) Sources: (1) Eco-SSL- Ecological Soil Screening Levels. U.S. EPA 2005. Revised March 2005; (2) U.S. EPA Region 5. August 22, 2003 http://www.epa.gov/reg5rcra/ca/ESL.pdf; (3) Oak Ridge National Laboratory (ORNL) publications
(b) U.S. EPA Region 9 Bioaccumulator (Hoffman, 1998).
(c) Efroymson et. al., 1997a. (d) Efroymson et. al., 1997b.
(e) Total DDT is the sum of 4,4′-DDT, 4,4′-DDE, and 4,4′-DDD.

nontarget background components. Therefore, although the MDLs may have been elevated for these analytes in some of the samples, the fact that MDLs were below screening benchmarks for the other 27 soil samples and the fact that none of these analytes were detected in any of the 34 soil samples at the site implies that these analytes are not present in the soil. Thus, they were not considered to be COPECs.

6.1.5 Receptors of Concern Selection. Following DTSC guidance (DTSC, 1996), the selection of ROCs takes into account species of special concern within California; the likelihood that the species is expected to occur based on existing conditions at the Ballfields Parcels; significance of the species to ecosystem function; availability of toxicity and life history data; and species sensitivity to COPECs. Because it is impractical to assess exposure to all potentially exposed species within a trophic group, representative species were selected as conservative surrogates for exposure to a group of taxonomically related and ecologically similar receptors. Representative species were chosen that have physiological, behavioral, and life history characteristics that represent chosen assessment endpoints for the ERA. The following sections provide details about the selection of ROCs for mammals, insectivorous birds, and birds of prey, and include short descriptions of pertinent life history characteristics.

Mammals. Mammals, such as the raccoon, the California vole, and the black-tailed deer have been observed foraging for prey on the Ballfields Parcels. These animals may be exposed to potential contaminants through their diet and from incidental ingestion of contaminated soil. The California vole is an herbivorous mammal that inhabits grassy meadows and consumes a diet consisting completely of plant material, such as stems, roots, seeds, and leaves. For these reasons it was chosen as a ROC to represent herbivorous mammals. The California vole (*Microtus californicus*) also represents an important prey species for upper-trophic-level predators, such as carnivorous birds.

Omnivorous mammals, such as the raccoon (*Procyon lotor*), are likely to be exposed to higher concentrations of organic COPECs from their consumption of animal tissue than herbivorous receptors, such as the California vole, which only consume plant tissue. Therefore, the raccoon was selected as a conservative representative of omnivorous mammals. In addition, the following reasons make the raccoon an ideal receptor for evaluation at the Ballfields Parcels:

- Raccoons inhabit dens in hollow trees lined with leaves, but may also use culverts, downed trees, woodchuck dens, and burrows of other animals (IT and CH2MHill, 2001);
- These animals are omnivorous opportunistic feeders that will consume fruits and blackberries, nuts, insects, earthworms, eggs, and virtually any animal and vegetable matter (U.S. EPA, 1993). It was assumed that the raccoon's diet was limited to terrestrial habitats, although raccoons will probably utilize a variety of habitats including wetlands and marshes which are present on the former Army BRAC-administered property;
- Raccoons are medium-sized mammals with a high percentage of lipid reserves (20-30% or more of body weight in the autumn) (U.S. EPA, 1993). Their high fat content makes them more likely to accumulate high concentrations of organic contaminants, such as DDT;
- The home range for raccoons varies depending on season and sex of the animal. Females tend to stay close to their den when nursing their young, and males tend to forage for prey further from their den. During winter months, hibernating animals travel little, and in the summer raccoons will travel up to several hundred acres. For the scoping-level and Phase I predictive assessments, the raccoon is conservatively assumed to spend all of its time on the Ballfields Parcels.

Table 12. COPECs Identified Through the Screening Process

Analyte	Maximum Concentration (mg/kg)	Soil Screening Benchmark (mg/kg)	Receptor Group	Location
Explosives				
2,6-DNT	0.2	0.033	mammal	Building 193
HMX	0.69	NA	NA	Building 193
Metals				
Antimony	0.67	0.27	mammal	Revetment 4
Cadmium	1.4	0.36	mammal	Revetment 4
Chromium	114	0.4	Invertebrate	Revetment 2
Cobalt(b)	55.8	13	Plant	Revetment 3
Copper	62	5.4	mammal	Revetment 4
Lead	234	11	bird	Revetment 4
Mercury	0.482	0.1	invertebrate	Building 193
Selenium	0.7	0.028	mammal	RSP
Silver	4.81	4.04	mammal	Building 193
Thallium	0.185	0.057	mammal	PDD
Zinc	110	6.62	invertebrate	Building 193
Semivolatile Organic Compounds				
2-Methylnaphthalene	0.0044	3.24	mammal	Revetment 3
Acenaphthylene	0.0032	682	mammal	Revetment 4
Anthracene	0.0036	1480	mammal	Revetment 1
Benz(a)anthracene	0.014	5.21	mammal	Revetment 5
Benzaldehyde(a)	0.033	NA	NA	Revetment 2
Benzo(a)pyrene	0.016	1.52	mammal	Revetment 4
Benzo(b)fluoranthene	0.026	59.8	mammal	Revetment 4
Benzo(g,h,i)perylene	0.022	119	mammal	Revetment 4
Benzo(k)fluoranthene	0.0085	148	mammal	Revetment 4
Caprolactam(a)	0.019	NA	NA	Revetment 3
Carbazole(a)	0.0025	NA	NA	SPN
Chrysene	0.019	4.73	mammal	Revetment 5
Dibenz(a,h)anthracene	0.004	18.4	mammal	Revetment 4
Fluoranthene	0.022	122	mammal	Revetment 4
Indeno(1,2,3-cd)pyrene	0.02	109	mammal	Revetment 4
Naphthalene	0.0025	0.099	mammal	Revetment 3
Phenanthrene	0.014	45.7	mammal	Revetment 1
Pyrene	0.019	78.5	mammal	Revetment 5
PCBs/Pesticides				
Total PCBs	0.07	0.371	mammal	Building 193
Total DDT(c)	0.36	0.0035	mammal	PDD

DDT – dichlorodiphenyltrichloroethane; HMX - 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane
mg/kg – milligram per kilogram
NA – not available
PDD – Perimeter Drainage Ditch; RSP – Revetment Spoils Pile; SPN – Spoils Pile N

(a) These COPECs were excluded from further quantitative analysis because no screening values or toxicity information is available.

(b) The maximum concentration of cobalt exceeded the selected soil screening benchmark of 13 mg/kg which was based on a plant receptor. The next lowest soil screening level from the Eco-SSL is 120 mg/kg based on a bird receptor, which is much higher than the maximum concentration detected. Therefore, exposure to cobalt in soil would not be expected to significantly affect wildlife receptors. Therefore, cobalt will be further evaluated in Section 6.2.3 as a COPEC for plants along with several other COPECs identified just for plants, rather than further evaluated in the dose assessment.

(c) Total DDT is the sum of 4,4′-DDT, 4,4′-DDE, and 4,4′-DDD.

Carnivorous Birds. A review of major exposure pathways to higher trophic levels indicates that there are potentially complete exposure pathways to carnivorous birds such as harriers, owls, and hawks. Exposure to these secondary and tertiary trophic consumers is through both the ingestion of prey that has accumulated COPECs from food and soil, as well as through the incidental ingestion of surface soil during foraging and preening. The northern harrier (*Circus cyaneus*) and burrowing owl (*Speotyto cunicularia*) have been observed at the Ballfields Parcels and were chosen as ROCs for the following reasons:

- Both are listed as "species of concern" by the State of California;
- The burrowing owl builds its nest in burrows in the ground, thus making it more susceptible to incidental ingestion of contaminated soil than tree-nesting birds;
- Diets of both species are predominantly small mammals; thus bioaccumulation of contaminants up the prey chain from small mammals is possible;
- The burrowing owl has a small home range of less than 2.5 acres (CDFG, 1999), whereas the site area is approximately 18 acres;
- Although the northern harrier has a large home range, over 975 acres (CDFG, 1999), the scoping assessment assumes that harriers will forage and feed on small mammals and vegetation solely in the area of the Ballfields Parcels (i.e., site use factor [SUF] =1).

Insectivorous Birds. Insectivorous birds may potentially be exposed to COPECs in soils at the Ballfields Parcels through foraging on prey that have bioaccumulated contaminants, or from incidental ingestion of contaminated soil or plants. Several species of birds have been observed including robins, cliff swallows, meadow larks, sparrows, and scrub-jays. Of these species, the American robin (*Turdus migratorius*) was selected as the ROC for the following reasons:

- The species is widespread in the area, building nests of mud lined with fine grass on a loose foundation of twigs and grass in trees, shrubs, or other supporting structures (Kaufman, 1996).
- Robins typically forage for earthworms by sight in shallow soil, frequenting open lawns and grassy fields (Kaufman, 1996).
- Robins are small birds with a home range of approximately 1.2 acres, indicating they may forage entirely within the property boundaries (i.e., SUF = 1) once they are nested in the area of the Ballfields Parcels.
- For the SLERA, the robin's diet is assumed to consist of 100% earthworms as conservative assessment of exposure. However, because the actual diet of a robin consists of at least 50% berries, such as blackberries, which are plentiful on the Ballfields Parcels (U.S. EPA, 1993), the Phase I predictive assessment considers both possible diets for the robin: a diet of 100% earthworms, and a diet of 50% earthworms and 50% berries (plants).

6.2 Phase I Predictive Assessment

The objective of the Phase I predictive assessment is to compare measured concentrations of COPECs at the site with contaminant-specific toxicity data believed to be protective of biota, to arrive at a hazard quotient for each species evaluated (DTSC, 1996). To accomplish this objective a dose assessment was performed for those COPECs identified in Table 12 to determine potential risks to upper-trophic level receptors. Three COPECs (benzaldehyde, caprolactam, and carbazole) were eliminated from further quantitative analysis because no toxicity data are available. Given the limited information on the uptake of toxicity of PAHs to wildlife, the dose assessment for PAHs was conducted by combining the PAHs into two groups: one summing the low-molecular-weight PAHs (LPAHs) and another summing the high-molecular-weight PAHs (HPAHs). The sum of all LPAHs and all HPAHs was used to derive the exposure point concentrations for the respective groups. HPAHs included benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene. LPAHs included phenanthrene, anthracene, naphthalene, 2-methylnaphthalene, and acenaphthylene. A prey-chain model was used to estimate the doses for completed exposure pathways using the methods described in the following sections.

To evaluate potential risks from soil to terrestrial plants at the Ballfields Parcels, the maximum detected concentration of chemicals detected in surface soil was compared to the plant-based screening benchmark, if one was available. The results of this comparison, including plant benchmarks selected for the comparison, are discussed in Section 6.2.3.

6.2.1 Exposure Assessment. The exposure assessment estimates the potential exposure of ROCs to COPECs identified at the site. An exposure model incorporating natural history information and species characteristics (including diet composition, ingestion rates, body weights, and foraging ranges) for each receptor was developed to evaluate the exposure of ROCs to bioaccumulative COPECs (Equation 1). Specific parameters of the exposure model for each ROC are identified in Table 13. In developing these dose models, it was assumed that ROCs are exposed to COPECs through consumption of contaminated prey and incidental ingestion of soil.

Table 13. Receptors of Concern and Exposure Factors

Species Community	Preliminary ROC	SUF[(a)]	IR_{soil}[(b)] (%)	IR $_{soil}$[(c)] (kg dry wt/day)	IR food [(d)] (kg dry wt/day)	Fraction of diet[(e)]	BW[(f)] (kg)
Mammals	Raccoon (*Procyon lotor)*	1	9.4	0.03	0.3	0.5 plant/worm	5.7
	California vole (*Microtus californicus)*	1	2.4	0.0003	0.012	1 plant	0.026
Carnivorous Birds	Northern Harrier (*Circus cyaneus)*	1	2	0.0006	0.03	1 mammal	0.349
	Burrowing Owl (*Speotyto cunicularia)*	1	2	0.0004	0.02	0.3 mammal 0.2 worm 0.5 plant	0.156
Insectivorous Birds	American Robin (*Turdus migratorius*)	1	10	0.0004	0.004	1 worm or 0.5 worm/plant	0.083

kg dry wt/day – kilograms dry weight per day

(a) SUF = site use factor, most conservative at 1 (unitless) assumes species spends 100% at the site.

(b) Ingestion rate of soil from Beyer et. al., 1994, presented as percentage of the dry food ingestion rate; northern harrier and burrowing owl based on lowest rate for birds; robin based on American woodcock.

(c) IR_{soil} = percentage of soil in diet × IR_{food}

(d) Ingestion rate of food based on equation 3-7 (mammals) and 3-3 (birds), from U.S. EPA, 1993; robin and vole ingestion rate based on Nagy, 2001.

(e) Fraction of diet that is plant, worm, or mammal. From U.S. EPA, 1993 and Thomsen, 1971.

(f) Body weight of receptors: raccoon (U.S. EPA, 1993); vole (CalEcotox); robin and northern harrier (DTSC, 2004); burrowing owl (Plumpton and Lutz, 1994).

The following dose model was used to assess exposure to upper-trophic-level ROCs and to characterize exposure:

$$Dose = \{[(C_{soil} \times IR_{soil}) + (C_{food} \times IR_{food})] \times SUF\}/BW \quad (1)$$

where:

Dose	=	daily dose resulting from ingestion of soil and food (mg/kg-day)
C_{soil}	=	concentration of COPEC in surface soil (mg/kg)
IR_{soil}	=	estimate of receptor's daily ingestion rate of surface soil (kg/day)
C_{food}	=	concentration of COPEC in food (e.g., C_{plant}, C_{worm}, C_{mammal}) (mg/kg)
IR_{food}	=	estimate of daily ingestion rate of food (kg/day)
SUF	=	site use factor (unitless)
BW	=	body weight (kg).

The exposure (and therefore dose) to each ROC is different; therefore, the exposure factors used in the dose equation vary slightly depending on the receptor being evaluated. For example, the estimated COPEC concentrations in prey tissue (C_{food}) were calculated based on soil chemistry data and chemical- and media-specific uptake factors that are reflective of the foraging habits of each receptor. Soil-to-biota uptake factors are expressed as simple ratios (bioaccumulation factors [BAFs]) or as regression equations. These uptake factors are used to calculate the COPEC concentration that has accumulated in biota (i.e., terrestrial plants, earthworms, or small mammals) from soil. The concentrations that were calculated using designated uptake factors for various biota are provided in Table 14. These concentrations are reflective of uptake values from soil to plants (C_{plant}), soil to worms (C_{worm}), and soil to small mammals (C_{mammal}) for each COPEC. The uptake factors (i.e., regression equations and BAFs) are presented in Appendix H.

The following receptor-specific dose models (Equations 2 through 6) are based on the dose equation (Equation 1) discussed above. These equations account for differences in exposure by incorporating species-specific (e.g., dietary composition) and chemical-specific (e.g., BAF) factors into the dose calculations. A descriptive table containing the parameters and calculated values for the dose equations using the site-wide surface soil maximum concentration of each COPEC is presented in Appendix I.

Raccoon Dose Assessment

$$Dose_{rac} = [(C_{soil} * IR_{soil}) + ((C_{plant} * f_{plant}) + (C_{worm} * f_{worm}))*IR_{food})]/BW_{rac} \quad (2)$$

where:

$Dose_{rac}$	=	daily dose of COPEC for a raccoon (mg/kg-day)
C_{soil}	=	concentration of COPEC in the soil (mg/kg_{soil})
IR_{soil}	=	incidental ingestion rate of soil for the raccoon (kg_{soil}/day)
C_{plant}	=	concentration of COPEC in plant (mg/kg) based on uptake factors (Table 14)
f_{plant}	=	fraction of diet that is plant tissue (kg_{plant}/kg_{food})
f_{worm}	=	fraction of diet that is worm tissue (kg_{worm}/kg_{food})
C_{worm}	=	concentration of COPEC in worm (mg/kg) based on uptake factors (Table 14)
IR_{food}	=	ingestion rate of food items for the raccoon (kg_{food}/day)
BW_{rac}	=	body weight of raccoon (kg).

__Vole Dose Assessment__

$$Dose_{vole} = [(C_{soil} * IR_{soil}) + ((C_{plant} * f_{plant}) * IR_{food})*SUF]/ BW_{vole} \quad (3)$$

where:

$Dose_{vole}$	=	daily dose of COPEC for a vole (mg/kg-day)
C_{soil}	=	concentration of COPEC in the soil (mg/kg_{soil})
IR_{soil}	=	incidental ingestion rate of soil for the vole (kg_{soil}/day)
f_{plant}	=	fraction of diet that is plant tissue (kg_{plant}/kg_{food})
C_{plant}	=	concentration of COPEC in plant (mg/kg) based on uptake factors (Table 14)
IR_{food}	=	ingestion rate of food items for the vole (kg_{food}/day)
BW_{vole}	=	body weight of vole (kg).

__Robin Dose Assessment__

$$Dose_{robin} = [(C_{soil} * IR_{soil}) + ((C_{plant} * f_{plant}) + (C_{worm} * f_{worm}))* IR_{food})*SUF] /BW_{robin} \quad (4)$$

where:

$Dose_{robin}$	=	daily dose of COPEC for a robin (mg/kg-day)
C_{soil}	=	concentration of COPEC in the soil (mg/kg_{soil})
IR_{soil}	=	incidental ingestion rate of soil for a robin (kg_{soil}/day)
f_{plant}	=	fraction of diet that is plant (kg_{plant}/kg_{food})
C_{plant}	=	concentration of COPEC in plant (mg/kg) based on uptake factors (Table 14)
f_{worm}	=	fraction of diet that is worm (kg_{worm}/kg_{food})
C_{worm}	=	concentration of COPEC in worm (mg/kg) based on uptake factors (Table 14)
IR_{food}	=	ingestion rate of food for the robin (kg_{food}/day)
BW_{robin}	=	body weight of robin (kg).

__Northern Harrier Dose Assessment__

$$Dose_{harrier} = [(C_{soil} * IR_{soil}) + (C_{mammal} * f_{mammal}) * IR_{food})*SUF]/BW_{harrier} \quad (5)$$

where:

$Dose_{harrier}$	=	daily dose of COPEC for a harrier (mg/kg-day)
C_{soil}	=	concentration of COPEC in the soil (mg/kg_{soil})
IR_{soil}	=	incidental ingestion rate of soil for the harrier (kg_{soil}/day)
C_{mammal}	=	concentration of COPEC in small mammal (mg/kg) based on uptake factors (Table 14)
f_{mammal}	=	fraction of diet that is small mammal (kg_{m}/kg_{food})
IR_{food}	=	ingestion rate of food items for the harrier (kg_{food}/day)
$BW_{harrier}$	=	body weight of harrier (kg).

__Burrowing Owl Dose Assessment__

$$Dose_{owl} = [(C_{soil} * IR_{soil}) + ((C_{plant} * f_{plant}) + (C_{worm} * f_{worm}) + (C_{mammal}* f_{mammal}))*IR_{food})*SUF]/BW_{owl} \quad (6)$$

where:

$Dose_{owl}$	=	daily dose of COPEC for the burrowing owl (mg/kg-day)
C_{soil}	=	concentration of COPEC in the soil (mg/kg_{soil})
IR_{soil}	=	incidental ingestion rate of soil for the owl (kg_{soil}/day)
f_{plant}	=	fraction of the owl's diet that is plant ($kg_{soi}l/kg_{plant}$)

Table 14. Contaminant Concentrations for Biota (Food Items) Based on Uptake Factors[(a)] and Maximum Concentrations Detected in Soil

Analyte	Maximum Concentration (C_{soil}) mg/kg	Soil to Plants (C_p) mg/kg dry weight	Reference	Soil to Worms (C_w) mg/kg dry weight	Reference	Soil to Small Mammals (C_m) mg/kg dry weight	Reference
Explosives							
2,6-DNT	0.20	0.47	Travis and Arms, 1988	0.20	Assumed[(e)]	0	ATSDR, 1998
HMX	0.69	4.67	CH2MHill, 2005	0.69	CH2MHill, 2005	0	Assumed negligible
Metals							
Antimony	0.67	0.027	U.S. EPA, 2005	0.67	U.S. EPA, 2005	0.001	U.S. EPA, 2005[(b)]
Cadmium	1.40	0.747	Bechtel-Jacobs, 1998	10.8	Sample et al., 1999	0.333	Sample et al., 1998b
Chromium	114.00	4.67	Bechtel-Jacobs, 1998	34.9	Sample et al., 1999	7.50	Sample et al., 1998b
Copper	62.00	9.92	Bechtel-Jacobs, 1998	31.9	Sample et al., 1999	14.0	Sample et al., 1998b
Lead	234.00	5.65	Bechtel-Jacobs, 1998	65.7	Sample et al., 1999	12.0	Sample et al., 1998b
Mercury	0.482	0.314	Bechtel-Jacobs, 1998	0.82	Sample et al., 1998a	0.026	Sample et al., 1998b
Selenium	0.70	0.343	Bechtel-Jacobs, 1998	0.71	Sample et al., 1999	0.577	Sample et al., 1998b
Silver	4.81	0.067	Bechtel-Jacobs, 1998	9.84	Sample et al., 1998a	0.019	Sample et al., 1998b
Thallium	0.185	0 [(c)]	Efroymson et al., 1997d	0.049	USACHPPM, 2004	0.019	Sample et al., 1998b
Zinc	110.00	65.3	Bechtel-Jacobs, 1998	399.7	Sample et al., 1999	109.4	Sample et al., 1998b
Semivolatile Organic Compounds							
HPAH[(f)]	0.1760	0.023	U.S. EPA, 2005b	0.234	Jager, 1998	0	U.S. EPA, 2005
LPAH[(g)]	0.034	0.415	U.S. EPA, 2005b	0.150	Jager, 1998	0	U.S. EPA, 2005
PCBs/Pesticides							
Total PCBs	0.07	0.00035	Travis and Arms, 1988	0.1	Jager, 1998[(d)]	0.245	Travis and Arms, 1988
Total DDT[(h)]	0.36	0.04	Bechtel-Jacobs, 1998	3.50	U.S. EPA, 2005	1.23	U.S. EPA, 2005[(b)]

C_{soil} – concentration detected in soil
C_p – concentration in the plant
C_w – concentration in the worm
C_m – concentration in the mammal
2,6-DNT – 2,6-dinitrotoluene
HMX - 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane

(a) Full uptake factor equations are presented in Appendix H.
(b) The regression equations cited in U.S. EPA (2005) for uptake of antimony and Total DDT to small mammals is based on a diet comprised of 100% invertebrates (worms). To be consistent with wildlife at this site, small mammal concentrations were based on a herbivorous diet (i.e., 100% plants) as in the case of the vole.
(c) Assumed to be negligible.
(d) To determine earthworm uptake factors for PCBs: regression equations from Jager, 1998 were used as presented in Appendix H.
(e) For lack of adequate uptake factors to worms, their concentrations were conservatively assumed to be equivalent to soil concentrations (U.S. EPA, 2005).
(f) HPAH - uptake factors based on benzo(a)pyrene
(g) LPAH - uptake factors based on naphthalene
(h) Total DDT represents the sum of 4,4′-DDD, -DDE, and –DDT.

C_{plant}	=	concentration of COPEC in plant (mg/kg) based on uptake factors (Table 14)
f_{worm}	=	fraction of owl's diet that is insects (represented by worms) (kg_{worm}/kg_{food})
C_{worm}	=	concentration of COPEC in worm (mg/kg) based on uptake factors (Table 14)
f_{mammal}	=	fraction of owl's diet that is small mammals (kg_{mammal}/kg_{food})
C_{mammal}	=	concentration of COPEC in small mammal (mg/kg) based on uptake factors (Table 14)
IR_{food}	=	ingestion rate of food for the owl (kg_{food}/day)
BW_{owl}	=	body weight of burrowing owl (kg).

A central element of the Phase I predictive assessment is a comparison of calculated doses to literature-derived toxicity reference values (TRVs). The dose that was determined for each ROC was compared to both a low and high TRV to characterize potential risks. Because this assessment is based on conservative assumptions of exposure, including the use of maximum concentrations detected, if the Phase I assessment concludes that negligible risk exists, there is strong support for no further action at the site. Exceedances of the risk threshold observed during the Phase I process would indicate that further evaluation may be necessary before a definitive decision regarding the nature and magnitude of risks can be made. The approach for characterizing risks is discussed further in Section 6.2.3.

6.2.2 Effects Assessment. For the purpose of evaluating the potential effects associated with the doses calculated in the exposure assessment, chemical- and receptor-specific TRVs were compared to the calculated doses. In general, a TRV is defined as a dose level at which a particular biological effect may be expected to occur in an organism, based on laboratory toxicological investigations. It is noteworthy that the calculation of TRVs is generally based on classes of animals (i.e., birds and mammals). Due to this limitation, TRVs commonly incorporate uncertainty factors, in addition to the toxicity-based reference doses, to account for a wide range of limitations, including differential interspecies sensitivities and lack of data.

The Navy, in consultation with EPA's Region 9 Biological Technical Assistance Group (BTAG) and DTSC (U.S. EPA, 2002a), has developed effects-based TRVs for birds and mammals. Each of these values represents a critical exposure level from a toxicological study and is supported by a published dataset of toxicological exposures and effects (DON, 1998). Rather than derive a single point estimate associated with specific adverse biological effects, high and low TRVs were derived for each receptor and COPEC to reflect the variability of parameters within an ecological risk context. The low TRV is a conservative value consistent with a chronic, no observed adverse effects level (NOAEL), which is defined as the highest documented exposure concentration where no effect was observed on ecological receptors for a given set of test conditions. It represents a level at which adverse effects are unlikely to occur, and is used to identify sites posing little or no risk. Conversely, the high TRV is a slightly less conservative estimator of potential adverse effects that is consistent with a mid-range adverse effect level. The high TRV represents a level above which adverse effects are anticipated to occur. In some cases, the high and low TRV were derived using a NOAEL and mid-range adverse effect level from the same study; in other cases, independent NOAELs and mid-range adverse effect levels were selected as the low and high TRVs, respectively.

Table 15 provides a summary of the available TRVs for each wildlife receptor class. For those COPECs where TRVs have not been published, toxicity data from the literature (i.e., ORNL, ATSDR) were used to develop the necessary TRVs. Available toxicity data were evaluated as described by DTSC guidance (1996) for the predictive risk assessment. Applicable chronic studies with available NOAELs and lowest observed adverse effects levels (LOAELs) were used.

6.2.3 Risk Characterization. The risk characterization for upper-trophic-level receptors combines the exposure and effects assessments to provide a quantitative estimate of the potential risks to the ROCs. For the Phase I risk characterization, an HQ was calculated by dividing the estimated daily doses derived using maximum concentrations detected by both the high and low TRVs according to the following equation:

$$HQ = dose/TRV \qquad (7)$$

As noted previously, conservative exposure parameters were used to calculate doses for each ROC and each COPEC. These doses were used to derive two HQs for each COPEC at the Ballfields Parcels, an HQ_{low} using the low TRV (based on the NOAEL) and an HQ_{high} using the high TRV (based on the mid-range adverse effect level). When the dose is lower than the low TRV (i.e., HQ_{low} <1), it is likely that no risk is present from the specific COPEC. When the dose exceeds the high TRV (i.e., HQ_{high} >1), adverse effects are expected; however, an HQ_{high}>1.0 is not required to elicit adverse effects. The HQ_{high} can change when conservative exposure parameters are adjusted to be more site-specific in the refined ERA, and therefore should be reevaluated for risk management purposes. When the dose exceeds the low TRV (i.e., HQ_{low} >1.0) and is less than the high TRV (HQ_{high} >1.0) in a Phase I predictive assessment, further evaluation should be considered but may not be absolutely necessary because these results fall within an area of great interpretive uncertainty. Therefore, the magnitude of the HQs, the level of confidence assigned to the TRV, and the degree of conservatism employed in deriving the exposure dose estimates need to be considered when determining whether further evaluation is warranted. The HQs (Equation 7) were calculated using the estimated doses from the dose models for each ROC. To further support a more site-specific dose assessment, a lead TRV of 1.6 mg dw/kg bw/day (Eco-SSL, U.S. EPA 2005) for avian receptors was also included in the calculations along with the Navy/BTAG TRV for lead so a range of HQs could be used to assess exposure to lead. Site-wide dose model calculations based on maximum detected concentrations are presented in Appendix I. The results indicated that for all the COPECs, HQs_{high} for all receptors of concern were below 1.0, ranging from 0.0000002 to 0.6. Results of the HQs_{low} are summarized in Table 16.

For those COPECs with an HQ_{low} >1.0 (indicated in Table 16), additional dose models were calculated using either the 95% upper confidence limit (UCL) of the mean or the maximum soil concentration, whichever was lower. Table 17 summarizes the 95% UCLs for each of the COPECs in surface soil.

The 95% UCLs were derived using surface soil (0-0.5 ft bgs) sampling results and the SAS™ software program. Appropriate statistical tests were applied to examine the distribution of the data to determine the most appropriate method(s) for calculating the 95% UCL. Criteria outlined in U.S. EPA (2002b) document *Calculating Exposure Point Concentrations at Hazardous Waste Sites* were used to determine the most appropriate statistical method for calculating an exposure point concentration that is representative of the UCL. In addition, the procedures used to calculate 95% UCLs were consistent with methods that are included in U.S. EPA software, ProUCL™. If possible, 95% UCLs were calculated using the following methods and the most appropriate UCL was selected based on the distribution of the data being either normal, lognormal, gamma or nonparametric:

- Chebychev's Non-Parametric
- Chebychev's Minimum Variance Unbiased Estimator (MVUE)
- Approximate Gamma
- Adjusted Gamma
- Student's T
- Land's Statistic.

Table 15. Summary of Available TRVs[a] for COPECs at the Ballfields Parcels

Chemical	Mammals		Birds	
	Low TRV (mg dw/kg bw-day)	High TRV (mg dw/kg bw-day)	Low TRV (mg dw/kg bw-day)	High TRV (mg dw/kg bw-day)
Explosives				
2,6-DNT[b]	0.2	1.5	NA	NA
HMX [i]	1	5	NA	NA
Metals				
Antimony[c]	0.059	0.59	NA	NA
Cadmium	0.06	2.64	0.08	10.4
Chromium[d]	3.28	13.14	1	5
Cobalt	1.2	20	NA	NA
Copper	2.67	632	2.3	52.3
Lead	1.0	240.64	0.014	8.75
Mercury (total)	0.027	0.27	0.039	0.18
	0.25	4.0	NA	NA
Selenium	0.05	1.21	0.23	0.93
Silver[e]	22	220	NA	NA
Thallium	0.48	1.43	NA	NA
Zinc	9.6	411	17.2	172
Semivolatile Organic Compounds				
LPAHs	26.9 [g]	269 [g]	50	150
HPAHs	32.5 [h]	325 [h]	1.31	32.8
PCBs/Pesticides				
Total PCBs	0.36	1.28	0.09	1.27
Total DDT[f]	0.8	16	0.009	1.5

2,6-DNT – 2,6-dinitrotoluene
DDT – dichlorodiphenyltrichloroethane
mg dw/kg bw-day – milligram dry weight per kilogram body weight per day
NA = Not available

(a) TRVs from U.S. EPA Region 9 BTAG (U.S. EPA, 2002a), except where noted.
(b) From ATSDR, 1998. Toxicological Profile for 2,4- and 2,6-dinitrotoluene.
(c) From U.S. EPA, 2005.
(d) From Sample et al., 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision.*
(e) From ATSDR, 1990. Toxicological Profile for Silver.
(f) Total DDT is the sum of 4,4′-DDT, 4,4′-DDE, and 4,4′-DDD.
(g) Wildlife International Ltd. 1985. An acute oral toxicity study on the bobwhite with naphthalene. Final Report, submitted to W.R. Landis Associates, Inc. Valdosta, GA.
(h) Patton, J.F., and M.P. Dieter. 1980. Effects of Petroleum Hydrocarbons on Hepatic Functions in the Duck. *Comparative Biochemistry and Physiology*, 65(c): 33-26.
(i) From CH2MHill, 2005.

Table 16. Summary of Site-Wide HQs_{low} Based on Maximum Concentrations Detected in Soil

HQ_{low}	California Vole	Robin [a] (100% Worms)	Robin [b] (50% Worms + 50% Plants)	Raccoon	Burrowing Owl	Northern Harrier
<1.0	antimony silver thallium Total DDT Total PCBs HPAH LPAH	copper selenium Total PCBs HPAH LPAH	copper mercury selenium zinc Total PCBs HPAH LPAH	2,6-DNT HMX antimony chromium copper selenium silver thallium Total DDT Total PCBs HPAH LPAH	copper selenium Total PCBs HPAH LPAH	cadmium chromium copper lead (Eco-SSL) mercury selenium zinc Total PCBs HPAH LPAH
>1.0	2,6-DNT HMX cadmium chromium copper mercury lead (BTAG) selenium zinc	cadmium chromium lead (Eco-SSL) lead (BTAG) mercury zinc Total DDT	cadmium chromium lead (Eco-SSL) lead (BTAG) Total DDT	cadmium mercury lead (BTAG) zinc	cadmium chromium lead (Eco-SSL) lead (BTAG) mercury zinc Total DDT	lead (BTAG) Total DDT

2,6-DNT – 2,6-dinitrotoluene
HMX - 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane
Total DDT - sum of 4,4′-DDT, 4,4′-DDD and 4,4′-DDE
HPAH – high molecular weight polycyclic aromatic hydrocarbons
LPAH – low molecular weight polycyclic aromatic hydrocarbons
(a) Assumes only an invertivorous diet for the robin.
(b) Assumes an omnivorous diet for the robin.

All of the HQs_{low} resulting from the reassessment using 95% UCLs are provided in Table 18. Full dose model tables can be found in Appendix J. In many cases, particularly for lead and Total DDT, the HQs_{low} based on the 95% UCL exposure concentrations are considerably lower than the HQs_{low} based on the maximum concentrations. Note also the HQs_{low} derived for each of the bird species for lead. All of the HQs_{low} calculated using the TRV_{low} obtained from the Eco-SSL [i.e., lead (Eco-SSL)] are below 1.0. Comparison of the HQs_{low} based on maximum and 95% UCL soil concentrations for 2,6-DNT and HMX were not significant. The HQ_{low} for 2,6-DNT using the 95% UCL was 1.0. The HQ_{low} for HMX remained 2.2 because the 95% UCL was greater than the maximum soil concentration so the maximum soil concentration was used in this additional dose assessment.

Background concentrations of inorganic metals in surface soils at the Ballfields Parcels were used to gauge potential risks to terrestrial receptors. The inorganic metals background data originates from the Army BRAC property in the Final Human Health and Ecological Risk Assessment for BRAC Property Hamilton Army Airfield (IT and CH2M Hill, 2001). Background soil concentrations for selenium and thallium were not derived for the Army BRAC property (see Table E-1 in Appendix E) because the data for these two analytes were mostly nondetect. However, these two analytes were evaluated at the detection limits in the background dose assessments using an average concentration of the data reported in Table E-1. The mean of 0.24 mg/kg, as reported on Table E-1, was used to assess

Table 17. Summary of the 95% UCL for COPECs

COPEC	unit	Number of Samples	Maximum Surface Soil Concentration	Average	Standard Deviation	95% UCL Soil Concentration
Explosives						
2,6-DNT	mg/kg	6	0.2	0.08	0.06	0.19
HMX[(a)]	mg/kg	6	0.69	0.18	0.26	0.80
Metals						
Cadmium	mg/kg	36	1.4	0.29	0.29	0.44
Chromium	mg/kg	36	114	48.69	32.75	72.49
Copper	mg/kg	36	62	21.37	13.00	25.88
Lead	mg/kg	36	234	33.61	45.60	66.74
Mercury	mg/kg	36	0.48	0.08	0.09	0.14
Selenium	mg/kg	36	0.7	0.33	0.15	0.44
Zinc	mg/kg	36	110	66.69	25.26	73.80
PCBs/Pesticides						
Total PCBs[(a)]	mg/kg	3	0.07	0.023	ND	ND
Total DDT[(b)]	mg/kg	18	0.36	0.06	0.09	0.12

2,6-DNT – 2,6-dinitrotoluene
HMX – 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane
ND – not determined because of insufficient sample size.
UCL – upper confidence limit
Total DDT is represented by the sum of 4,4′-DDD, DDE, and DDT compounds.
(a) The maximum concentration was used as the soil concentration.
(b) The 95% UCL for Total DDT included analytical data obtained during the PA/SI, as well as, the surficial soil results (0-2 inches bgs) from the Army BRAC Total DDT Investigation in March 2003.

exposure to selenium, and for thallium, the detection limits were averaged to obtain a value of 1.5 mg/kg. The calculated HQs for each naturally occurring COPEC and each ROC using background concentrations are presented in Appendix K. Table 19 presents the HQs_{low} for site background risks.

To evaluate potential risk to plants, a comparison of the maximum concentrations detected in surface soil to available conservative screening benchmarks for plants was conducted and provided in Table 20. Six COPECs, Total DDT, cobalt, lead, mercury, silver, and zinc, exceeded relevant plant screening benchmarks primarily in the former ordnance magazine areas and Revetments 3 and 4 (Table 20). Concentrations of cobalt, lead, and mercury were above the screening benchmark in only one AOPC. Silver, zinc, and Total DDT exceeded the benchmark in more than one AOPC. Maximum concentrations of nickel and vanadium were greater than the screening benchmark, but less than background concentrations; therefore, these two COPECs are not considered to be of significant ecological concern with respect to plants.

In the *Final Human Health and Ecological Risk Assessment for BRAC Property Hamilton Army Airfield* (IT and CH2M Hill, 2001), discussion was provided regarding numerous field studies and biological surveys that have been conducted at the Army BRAC Property. Although field observations alone are not in themselves strong evidence of minimal effects to the ecosystem, they can provide a source of evidence for assessing adverse impacts on the ecological communities. General qualitative observations of community diversity made during past biological studies and during PA/SI sampling at the Ballfields Parcels suggest that the area supports viable ecosystems. Please note that adverse effects to plants or other organisms can also result in reduced success of more sensitive species and selection of resistant species which are not readily identifiable effects. Casual observations by various investigators of the existing grassland, including the PA/SI sampling crew, suggest that the cover is complete, and there are no obvious indications of stressed vegetation. This suggests that either the chemicals are not as toxic to the grasses under field conditions as they are to crops under laboratory conditions (the basis for the TRVs), the chemicals are limited in their bioavailability, or impacts to vegetation are not visually obvious (IT and CH2M Hill, 2001). Hawks, quail, songbirds, small mammals (such as rabbits), and deer are routinely observed foraging and using the grassland habitat at the Ballfields Parcels and have been for several years since the airfield ceased operations. Again, whereas this information does not conclusively indicate there are no adverse impacts to the ecosystem at the Ballfields Parcels, casual observations made during past studies and the PA/SI sampling activities seem to indicate that the area does support a viable ecosystem.

6.3 Uncertainty Associated With Ecological Risk Estimates

The overall objective of the Phase I predictive assessment was to evaluate the potential for adverse effects to ecological receptors from exposure to contaminants in surface soil under current conditions. As appropriate for a Phase I assessment, conservative assumptions were used throughout the analysis to minimize the likelihood of incorrectly concluding that contaminants do not pose a risk, when in fact, the opposite is true. The following sections discuss the uncertainties associated with the Phase I predictive assessment.

Site Foraging Assumptions. Although appropriate for a Phase I analysis, the exposure dose calculations assumed that individual wildlife receptors would forage only within the boundaries of the Ballfields Site or individual AOPCs. Although it is possible that an individual small mammal such as the California vole could limit its daily foraging activities to within the boundaries of the site or specific AOPC, this is an unrealistic assumption for other wildlife with larger foraging ranges. For these other species, individual receptors could be exposed to soil contamination at the Ballfields Parcels; however, they would also forage in the other areas not impacted by historical activities at HAAF. As a result, the dose calculations for these wildlife receptors overestimate the actual exposures encountered.

Use of Presumptive Data. The analytical results for both 2,6-DNT and HMX were qualified by the analytical laboratory as "JN" (see Table C-1 in Appendix C). The "J" indicates that the associated numerical value is an estimated quantity, less than the MRL, but greater than or equal to the MDL. The "N" designates the concentrations as presumptive evidence of the presence of the compound (i.e., a tentative identification). These two compounds were tentatively detected in surface soil around Buildings 191 and 193 where arms and ammunition were reportedly stored, not manufactured, in the 1930s. Given the chemical properties of these compounds (e.g., high mobility in soil and photolysis), the length of time since explosive compounds were stored on-site (70 + years), and because no other associated explosive compound was detected in soil, the tentative identification of 2,6-DNT and HMX is questionable, and assuming their presence results in overestimating the risk for the California vole.

Use of Maximum Soil Calculations. Maximum COPEC soil concentrations for the Ballfields Parcels and individual AOPCs were used to estimate both incidental and dietary exposures to the selected wildlife receptors. Maximum soil concentrations were used to provide a "worst case" assessment of potential ecological risks associated with exposure to COPECs; however, this means that individual receptors are assumed to be incidentally exposed and receive all their entire dietary intake from prey that have accumulated COPECs in their tissues from the location of highest concentration. This is a conservative assumption that results in an overestimation of the exposure doses and the resulting HQs; the magnitude depends on the statistical distribution of the analytical results.

Table 18. Summary of Dose Model Results using 95% UCL Soil Concentrations

Species	COPEC	95% UCL C_{soil} (mg/kg)	Dose (mg/kg-day)	TRV_{low}	HQ_{low}
Vole	Cadmium	0.44	0.187	0.06	3.1
	Chromium	72.49	2.207	3.28	0.7
	Copper	25.88	3.543	2.67	1.3
	Lead	66.74	2.062	1	2.1
	Mercury	0.14	0.045	0.027	1.7
	Selenium	0.44	0.101	0.05	2.0
	Zinc	73.80	25.036	9.6	2.6
	2,6-DNT	0.19	0.205	0.2	1.0
	HMX	0.69	2.163	1	2.2
Robin[c] (50% Worms + 50% Plants)	Cadmium	0.44	0.115	0.08	1.4
	Chromium	72.49	0.956	1	1.0
	Lead (Eco-SSL)[a]	66.74	0.965	1.6	0.6
	Lead (BTAG)[b]	66.74	0.965	0.014	68.9
	Total DDT	0.12	0.034	0.009	3.8
Robin[d] (100% Worms)	Cadmium	0.44	0.209	0.08	2.6
	Chromium	72.49	1.419	1	1.4
	Lead (Eco-SSL)[a]	66.74	1.473	1.6	0.9
	Lead (BTAG)[b]	66.74	1.473	0.014	105.2
	Mercury	0.14	0.012	0.039	0.3
	Zinc	73.80	17.257	17.2	1.0
	Total DDT	0.12	0.067	0.009	7.5
Raccoon	Cadmium	0.44	0.126	0.06	2.1
	Lead	66.74	1.054	1	1.1
	Mercury	0.14	0.010	0.027	0.4
	Zinc	73.80	10.996	9.6	1.1
Owl	Cadmium	0.44	0.140	0.08	1.8
	Chromium	72.49	1.124	1	1.1
	Lead (Eco-SSL)[a]	66.74	1.198	1.6	0.7
	Lead (BTAG)[b]	66.74	1.198	0.014	85.6
	Mercury	0.14	0.012	0.039	0.3
	Zinc	73.80	16.217	17.2	0.9
	Total DDT	0.12	0.063	0.009	7.0
Harrier	Lead (Eco-SSL)[a]	66.74	0.706	1.6	0.4
	Lead (BTAG)[b]	66.74	0.706	0.014	50.4
	Total DDT	0.12	0.062	0.009	6.9

Shading indicates $HQ_{low}>1.0$.

(a) Based on a lead TRV_{low} of 1.6 mg dw/kg bw/day (Eco-SSL, U.S. EPA 2005).

(b) Based on the Navy/BTAG lead TRV_{low} of 0.014.

(c) Assumes an omnivorous diet for the robin.

(d) Assumes only an invertivorous diet for the robin.

Table 19. Summary of HQs_{low} Associated with Background Concentrations

Species	Analyte	Background Soil (mg/kg)	TRV_{low}	HQ_{low}
Vole	Antimony	0.37	0.059	0.20
	Cadmium	0.64	0.060	3.87
	Chromium	107	3.280	0.99
	Copper	48.8	2.67	1.77
	Lead	30.7	1.0	1.19
	Mercury	0.42	0.027	4.86
	Selenium[a]	0.24	0.05	1.03
	Silver	0.21	22	0.0002
	Thallium[a]	1.5	0.48	0.036
	Zinc	92	9.6	2.95
Robin[d] (50% Worms + 50% Plants)	Antimony	0.37	NA	NA
	Cadmium	0.64	0.08	1.93
	Chromium	107	1	1.41
	Copper	48.8	2.3	0.46
	Lead (Eco-SSL)[b]	30.7	1.6	0.31
	Lead (BTAG)[c]	30.7	0.014	35.5
	Mercury	0.42	0.039	0.66
	Selenium	0.24	0.23	0.05
	Silver	0.21	NA	NA
	Thallium	1.5	NA	NA
	Zinc	92	17.2	0.64
Robin[e] (100% Worms)	Antimony	0.37	NA	NA
	Cadmium	0.64	0.08	3.53
	Chromium	107	1	2.09
	Copper	48.8	2.3	0.63
	Lead (Eco-SSL)[b]	30.7	1.6	0.48
	Lead (BTAG)[c]	30.7	0.014	54.3
	Mercury	0.42	0.039	0.93
	Selenium	0.24	0.23	0.07
	Silver	0.21	NA	NA
	Thallium	1.5	NA	NA
	Zinc	92	17.2	1.08
Raccoon	Antimony	0.37	0.059	0.21
	Cadmium	0.64	0.060	2.81
	Chromium	107	3.280	0.47
	Copper	48.8	2.67	0.43
	Lead	30.7	1.0	0.54
	Mercury	0.42	0.027	1.04
	Selenium	0.24	0.05	0.25
	Silver	0.21	22	0.0006
	Thallium	1.5	0.48	0.04
	Zinc	92	9.6	1.25
Owl	Antimony	0.37	NA	NA
	Cadmium	0.64	0.08	2.32
	Chromium	107	1	1.63
	Copper	48.8	2.3	0.79
	Lead (Eco-SSL)[b]	30.7	1.6	0.43
	Lead (BTAG)[c]	30.7	0.014	49.4
	Mercury	0.42	0.039	0.94
	Selenium	0.24	0.23	0.13
	Silver	0.21	NA	NA
	Thallium	1.5	NA	NA
	Zinc	92	17.2	1.01

Table 19. Summary of HQs_{low} Associated with Background Concentrations (Continued)

Species	Analyte	Background Soil (mg/kg)	TRV_{low}	HQ_{low}
Harrier	Antimony	0.37	NA	NA
	Cadmium	0.64	0.08	0.26
	Chromium	107	1	0.80
	Copper	48.8	2.3	0.54
	Lead (Eco-SSL)[(b)]	30.7	1.6	0.30
	Lead (BTAG)[(c)]	30.7	0.014	33.8
	Mercury	0.42	0.039	0.07
	Selenium	0.24	0.23	0.15
	Silver	0.21	NA	NA
	Thallium	1.5	NA	NA
	Zinc	92	17.2	0.55

NA – not available.
Shading indicates HQ_{low} > 1.0.
(a) Background soil concentrations were assessed at the detection limits for selenium and thallium.
(b) Based on a lead TRVlow of 1.6 mg dw/kg bw/day (Eco-SSL, U.S. EPA 2005).
(c) Based on the Navy/BTAG lead TRVlow of 0.014.
(d) Assumes an omnivorous diet for the robin.
(e) Assumes only an invertivorous diet for the robin.

Table 20. Comparison of Available Plant Screening Benchmarks to Maximum Concentrations Detected in Soil

Chemical	Site-Wide Maximum Concentration (mg/kg)	Plant Benchmark (mg/kg)	Benchmark Source[(a)]	Background Soil Concentration (mg/kg)[(b)]	AOPC Where Benchmark is Exceeded
Metals					
Antimony	0.67	5	Eco-SSL	0.37	None
Arsenic	16.7	18	U.S. EPA Region 5	16.7	None [(c)]
Beryllium	1.1	10	ORNL	1.03	None
Cadmium	1.4	32	Eco-SSL	0.64	None
Cobalt	55.8	13	Eco-SSL	27.6	Revetment 3[(d)]
Copper	62	100	U.S. EPA Region 5	48.8	None
Lead	234	120	Eco-SSL	30.7	Revetment 4
Mercury	0.482	0.3	ORNL	0.42	Building 193[(d)]
Nickel	67	30	U.S. EPA Region 5	113.5	NA[(c)]
Selenium	0.7	1	ORNL	NA	None
Silver	4.81	2	ORNL	0.21	Building 193, Revetment 3, Revetment 4
Thallium	0.185	1	ORNL	NA	None
Vanadium	94.7	2	ORNL	118	NA[(c)]
Zinc	110	50	ORNL	92	Building 191, Building 193, PDD, and Revetment 2[(d)]
Semivolatile Organic Compounds					
Phenol	0.014	70	ORNL	NA	None
Volatile Organic Compounds					
m,p-Xylenes	0.002	100	ORNL	NA	None
o-Xylenes	0.0011	1	ORNL	NA	None
PCBs/Pesticides					
Total PCB	0.07	40	ORNL	NA	None
Total DDT[(e)]	0.36	0.0025	ORNL	NA	Building 193, SPN

AOPC – area of potential concern; DDT – dichlorodiphenyltrichloroethane; NA – not applicable; PCB – polychlorinated biphenyl; PDD – Perimeter Drainage Ditch; SPN – Spoils Pile N; SSL – soil screening level; Shading indicates chemicals retained as a COPEC
(a) Sources: (1) Eco-SSL- Ecological Soil Screening Levels. Revised March 2005; (2) U.S. EPA Region 5. August 22, 2003 http://www.epa.gov/reg5rcra/ca/ESL.pdf; (3) Oak Ridge National Laboratory's (ORNL) Efroymson et. al., 1997c.
(b) Background concentrations were represented by BRAC ambient soil data presented in IT and CH2M Hill, 2001.
(c) Maximum concentrations are less than background concentrations (see Table 7).
(d) All other AOPCs contained concentrations less than background concentrations.
(e) Total DDT represents the sum of the 4,4′-DDD, DDE, and DDT compounds.

Calculation of "Total" DDT Concentrations. In order to be consistent with the area-wide DDT evaluation performed in 2003 (see Section 2.3.4), the analytical results for the 4,4′- isomers of DDD, DDE, and DDT were summed to estimate the Total DDT concentration for wildlife exposure dose calculations. Although this introduces some uncertainty into the assessment, a review of the analytical data provided in Appendix C indicates that where detected, the 2,4′-DDT isomer concentrations were typically up to an order of magnitude less than the 4,4′- isomers. Moreover, the majority of the maximum concentrations of the 2-4' DDT isomers were below available screening benchmarks. Consequently, this calculation procedure had a minimal effect on the calculation of the Total DDT concentrations and did not impact the conclusions of this evaluation.

Lack of Available Screening Benchmarks. No screening benchmarks for plants are available for PAH and explosive compounds; in addition, no plant-based benchmarks are available for barium and chromium. Furthermore, screening benchmarks for mammals are not available for TPH, HMX, benzaldehyde, caprolactam, and carbazole. The lack of these benchmarks, however, conservatively impacted the selection of COPECs for further evaluation in the Phase I dose assessment because any COPEC without a screening benchmark was retained as a COPEC.

Benchmarks for Plants. According to ORNL (Efroymson et al., 1997c), there is a low level of confidence in the majority of plant-based benchmarks listed in Table 20, due to either the small number of studies to which the benchmarks were based upon and/or the limited variety of plant species that were studied. In addition, there are interspecies differences between the laboratory plant species (e.g., soybean, corn, spruce) and plant species observed at the Ballfields Parcels (e.g., blackberry bushes, barley, fescue). This lack of confidence in the screening benchmarks reveals a level of uncertainty with the potential risk to plants.

Lack of Available TRVs. Due to the lack of available TRVs for some of the COPECs (e.g. benzaldehyde, caprolactam, and carbazole), the Phase I predictive assessment could not determine whether the specific COPEC poses a potential threat to ecological receptors at the Ballfields Parcels. For this reason, the Phase I predictive assessment may be underestimated.

Use of Surrogate TRVs. The naphthalene and benzo(a)pyrene TRVs were used as surrogates for the summed LPAH and HPAH, respectively. Risk from individual components or sums that was estimated using a TRV for a surrogate chemical or mixture may be over- or underestimated, depending on how the toxicity of the individual component relates to the mixture.

Toxicity Data for Development of the TRVs. Uncertainties are associated with the quantity and variable quality of literature-derived toxicity data. The TRVs used in this assessment were obtained from three widely accepted sources: BTAG (U.S. EPA, 2002a), U.S. EPA's Eco-SSL documents (U.S. EPA, 2005), and ORNL (Sample et al., 1996). However, TRVs for the same chemical can vary significantly among these sources. For example, the avian NOAEL for lead in the Eco-SSL is 1.63 mg/kg/d, whereas the BTAG avian NOAEL (used in this risk assessment) is 0.014 mg/kg/d. The BTAG avian TRV is based on studies that employed lead acetate, a form of lead not commonly found in nature. Lead acetate is highly soluble and more bioavailable than inorganic lead or other lead salts, making it more toxic than other forms of lead that are commonly found in the environment. The Eco-SSL TRVs were developed using only studies of the effects of inorganic lead compounds, which are more relevant at most sites, including the Ballfields Parcels. As a result, the risk to birds from exposure to lead at the Ballfields Parcels when the BTAG lead TRV is used in the dose assessment is likely overestimated.

Magnitude of Difference between Low TRV and High TRV. Low TRVs derived by the BTAG, U.S. EPA Eco-SSL, ORNL, and USACHPPM process represent a no effect level, whereas the high TRVs represent the mid-range of effects levels found in the literature. There is a critical point on the dose-response curve at which effects will first be seen, but that dose is not known. The difference between the low and high TRVs is typically an order of magnitude, and HQs between 1.0 and 10 give an indication of how close the dose may be to the no effect or low effects levels represented by the TRVs. When the difference between the low and high TRV for a COPEC is very great, there is a high degree of uncertainty regarding where effects may first be seen. The difference between the low and high TRVs is greater than two orders of magnitude for some COPECs, such as avian TRVs for cadmium and lead (i.e., using the BTAG TRV) and Total DDT. A large difference in the high and low TRV for a COPEC increases the uncertainty of risk conclusions based on the magnitude of the low benchmark HQ because it is unknown whether the dose estimated is approaching where first-effects may be found.

Potential Exposures. As discussed in Section 6.1.2, the PDD is the only area at the site having a potential surface water feature. As indicated on the CSM (Figure 9), ingestion of surface water for terrestrial receptors is considered a minor exposure pathway and was therefore not included in the dose assessments. Because this exposure pathway was not included in the Phase I predictive assessment, the dose calculations for these wildlife receptors may have been underestimated. This pathway was determined to be insignificant at the Ballfields Parcels for the following reasond: The source of this water is from a permitted storm water pumping station operated by the City of Novato and may result in temporary or episodic pooling of water following rainfall events. Because the majority of the water flow comes from a permitted stormwater discharge facility operated by the City of Novato, and all sediments and vegetation were removed down to the concrete lining in 1998, the majority of impacts to the PDD that were a result of historical site activities would have been primarily addressed by the 1998 removal action. Thus, exposure to terrestrial receptors is expected to be minimal.

Section 7.0: CONCLUSIONS AND RECOMMENDATIONS

This PA/SI was conducted by the Navy in order to determine if the Ballfields Parcels are suitable for transfer to the CCC for seasonal wetlands reuse. In order to determine suitability for transfer, the property was evaluated through a PA/SI to determine if chemicals in soil and groundwater pose a significant threat to human health or the environment. Conclusions of the PA/SI are provided below along with recommendations for property transfer.

7.1 Conclusions

Chemicals detected in soil samples collected during the PA/SI mostly consisted of metals, a few SVOCs and VOCs at very low concentrations, and Total DDT. Explosives, TPHs, and PCBs were either not detected, or detected infrequently at very low concentrations in soils. Chemicals in groundwater consisted mostly of metals, with infrequent and very low detections of some SVOCs, VOCs, and TPHs.

7.1.1 Human Health Screening Evaluation. Using the analytical data obtained from the PA/SI, a human health screening-level risk evaluation was conducted to determine if chemicals in soil and groundwater were associated with unacceptable risk levels. For the human health evaluation, an unrestricted residential land use scenario was assumed in accordance with DTSC guidance (DTSC, 1994), rather than using the more applicable site recreational visitor (or recreational) scenario that describes the site as it is currently used, and will likely be used in the future after the seasonal wetlands have been developed.

Under the unrestricted residential land use scenario, the most likely routes of exposure to chemicals in soil for the hypothetical resident would be via direct contact (i.e., inhalation, incidental ingestion, and dermal contact) similar in nature to the exposure experienced by the site recreational visitor, but differing primarily through exposure frequency (i.e., the number of days per year the individual comes into contact with the soil) and duration of exposure (i.e., the number of years the receptor is at the site). The exposure frequency and exposure duration are much greater for the resident compared to the site recreational visitor. Unlike the site recreational visitor who is expected to only come in contact with chemicals volatilizing from groundwater, exposure to chemicals in groundwater for the hypothetical residential receptor is conservatively based on the assumption that groundwater beneath the site is used for potable purposes, even though this groundwater is not appropriate for domestic use due to its high TDS, very low recharge rate, decreasing saturated aquifer thickness, and the lack of an adequate confining layer for sanitary well seals. In addition to the direct contact pathways, vapor intrusion to indoor air from chemicals volatilizing from soil and groundwater was evaluated for the hypothetical residential receptor. Risk and hazard for VOCs in groundwater were estimated using the DTSC-modified Johnson and Ettinger spreadsheet, whereas the risk and hazard for VOCs in soil were estimated using U.S. EPA's Johnson and Ettinger spreadsheet modified to account for DTSC-specific toxicity values.

Potential risk to human health as a result of direct contact with chemicals present in the soil and groundwater was evaluated by comparing maximum concentrations detected in soil and groundwater to residential U.S. EPA Region 9 PRGs. These estimated risks were then summed with the indoor air risks to obtain estimate total cancer risks and noncancer HI. Results of the human health screening-level (Table 10) evaluation indicate that the estimated total cancer risk and noncancer HI for soil is 5.3×10^{-6} and 0.3, respectively, slightly above U.S. EPA's target risk of 1.0×10^{-6} and less than the noncancer HI of 1.0. Note that the majority of the cancer risk for soil is attributable to the indoor air risk for methylene chloride. As explained in Section 5.5, a large amount of uncertainty is associated with this risk estimate due to the methodology used to estimate soil to indoor air concentrations.

In addition, the analytical data collected at the site indicate that the indoor air pathway is not a significant exposure to the hypothetical resident. A total of 53 VOCs were analyzed in a total of 32 soil samples collected during the PA/SI sampling activities. Acetone was detected in 3 of 32 samples, 2 of which were "J" qualified, meaning the result is an estimate between the method detection limit (MDL) and the method reporting limit (MRL). *m,p*-xylenes, *o*-xylene, and methylene chloride were detected in only 1 sample out of 32, again, each qualified with a "J". Because the frequency of VOC detections was low and the detected concentrations were extremely low (i.e., nearly all "J" qualified), the indoor air inhalation pathway would not be a significant exposure of concern at the Ballfields Parcels.

All detections of lead but one (in Revetment 4) are less than the California-modified PRG of 150 mg/kg. The maximum concentration of lead in Revetment 4, however, is much less than the other U.S. EPA Region 9 PRG of 400 mg/kg. Aside from the indoor air risk, the cancer risk associated with the direct contact exposure pathways is 1.6×10^{-6}. The individual cancer risk levels of each of the COPCs contributing to the 1.6×10^{-6} estimated total cancer risk level were less than 1.0×10^{-6} (Table F-1). Maximum concentrations of the three primary chemical contributors to the total site cancer risk were detected in three different AOPCs (Revetment 2, Building 193, and Revetment 4, respectively, as shown in Table F-1). These AOPCs are located at either end of the property and in the middle as shown on Figure 7, so the assumption that an individual would come into contact with each of these maximum concentrations everyday for an extended period of time is very conservative. The use of the conservative hypothetical residential receptor artificially inflates the cancer risk estimates for the Ballfields Parcels because exposure to chemicals in soil would not be expected to be as frequent or for such an extended period of time for a site recreational visitor compared to the residential receptor. Given the conservative nature of the screening-level risk assessment, which evaluates the Ballfields Parcels under a hypothetical residential scenario, rather than the more appropriate site recreational visitor, the estimated total cancer risk estimate and noncancer HI estimated for the Ballfields Parcels indicate there is no significant threat to human health.

The estimated total cancer risk associated with groundwater is 1.3×10^{-2} and the estimated HI is 14. Ingestion of metals (arsenic and vanadium) in groundwater is the primary reason for the elevated risk/hazard estimates. Groundwater beneath the Ballfields Parcels is not suitable for any beneficial use, including domestic, agricultural, and industrial use, because of high TDS, very low recharge rates, decreasing saturated aquifer thickness, and the lack of an adequate confining layer for sanitary well seals. As such, even if a residential housing development were to be constructed on the Ballfields Parcels, groundwater beneath the property would not be used for consumption. Therefore, the only viable exposure route of concern for either the hypothetical resident, or the more applicable site recreational visitor, is inhalation of chemicals that volatilize from groundwater. The conservative groundwater to indoor air estimate for the hypothetical receptor is less than 1×10^{-6}, so inhalation of chemicals volatilizing from groundwater is not a significant exposure pathway. Because groundwater will not be used for drinking water, regardless of the type of receptor, the estimates of groundwater risks and hazards overestimate the actual risks associated with the site. Therefore, potential risk to human health should be deemed acceptable for the Ballfields Parcels under current land use conditions.

7.1.2 Ecological Risk Evaluation. The potential for adverse effects to upper-trophic-level receptors and terrestrial plants resulting from exposure to contaminants in soil was evaluated by conducting a Phase I predictive assessment. For upper-trophic-level receptors, a dose assessment, using a prey-chain model to estimate the doses, was performed on concentrations of COPECs from surface soil samples at the site to determine potential risks. COPECs evaluated in the dose assessment included bioaccumulative compounds and those chemicals exceeding ambient background concentrations or ecological benchmarks. The Phase I predictive assessment consisted of two dose assessments. The first dose assessment was conducted using maximum soil concentrations. The second dose assessment was conducted to examine a subset of COPECs that were determined to have HQs_{low} above 1.0 in the first dose assessment. For the second dose modeling effort, however, 95% UCL soil concentrations were used, rather than maximum soil concentrations (unless the maximum concentration was lower), in order to take into consideration the concentrations and spatial variability of the chemicals detected in surface soil at the site. Both dose assessments included two low TRVs for the avian receptors for lead: the Navy/BTAG TRV (U.S. EPA, 2002a) and the Eco-SSL TRV (U.S. EPA, 2005) as a means to provide a range of risk results for this COPEC. Therefore, two sets of HQs for lead are provided, which are designated by the TRV source [i.e., lead (BTAG) and lead (Eco-SSL)]. In addition to assessing site-related exposure to the COPECs, dose modeling was conducted using background soil concentrations in order to determine the potential risk associated with naturally occurring analytes for risk comparisons.

The results of the dose assessment based on maximum soil concentrations indicated that all of the HQs_{high} for each of the ROCs were well below 1.0, and therefore no further assessment is required of these results. However, results of this dose assessment indicated that some of the HQs_{low} for various metals, Total DDT, 2,6-DNT, and HMX were above 1.0 for the various receptors as summarized in Table 16. Therefore, additional evaluation focused on the HQs_{low} for these specific COPECs and associated ROCs. Figures 10 through 16 present graphical comparisons of HQs_{low} based on maximum, 95% UCL, and background soil concentrations for each of the ROCs. Note that comparisons of HQs_{low} for lead (BTAG) for each of the avian receptors have been placed on Figure 16 for each of the ROCs because of the large scale required for these HQs_{low} as compared to the HQs_{low} for the other COPECs. The results of these graphical comparisons show that the risk is much lower when 95% UCL soil concentrations are used in place of maximum soil concentrations.

In addition, Figures 10 through 16 show that risks for the majority of the metals detected during the PA/SI are similar to the risks presented from background concentrations, and the background risk is higher than the risk associated with the 95% UCL soil concentrations for antimony, cadmium, chromium, copper, mercury, and zinc. Therefore, because the low TRV HQs were either less than 1.0, or less than the respective low TRV HQ for background concentrations, these six metals are not associated with unacceptable risk at the Ballfields Parcels for any of the ROC. Lead and selenium low TRV HQs for the raccoon are less than or at the threshold criterion of 1.0, and therefore are not associated with unacceptable risk for this ROC as well. For the vole (Figure 10), lead and selenium are the only COPECs with an HQ_{low} greater than one that also is greater than the background HQ_{low}. For the avian receptors (Figures 11, 12, 14, and 15), the HQs_{low} for lead (Eco-SSL) are all below 1.0. For lead (BTAG) comparisons shown on Figure 16, risks associated with the 95% UCL are less than twice the risk from background concentrations. Superimposed on Figure 16 are the risks associated with the lead (Eco-SSLs), which demonstrates the significant differences between the estimates of risk, at times varying by a factor of 100, depending on the specific TRV (i.e., BTAG vs. Eco-SSL) used to estimate risk. One of the uncertainties noted in Section 6.3 is the variability of the low TRV for lead among the literature sources. The BTAG TRV is based on exposure to lead acetate, an extremely bioavailable form of lead. The BTAG TRV for lead is significantly lower than other widely accepted TRVs such as those from ORNL (Sample et al., 1996) (i.e., 1.13 mg/kg bw-day based on lead acetate) or the U.S. EPA Eco-SSL (2005) (i.e., 1.6 mg/kg bw-day). The U.S. EPA TRV for lead was developed following an extensive literature search and graphical plotting of various toxicity data (most of which were for lead acetate), from which the TRV was selected as the highest bounded NOAEL, lower than the lowest bounded LOAEL for reproduction, growth, or survival. General concerns about the BTAG TRV (DON, 1998) for birds make it difficult to adequately assess the risk from lead at the Ballfields Parcels and present a large amount of uncertainty with respect to interpreting the HQs.

A graphical comparison of HQs_{low} for Total DDT is shown on Figure 17 for maximum and 95% UCL soil concentrations. As shown on Figure 17, estimates of risk are more than halved to a maximum of 8 when the 95% UCL soil concentrations are used in the dose assessment.

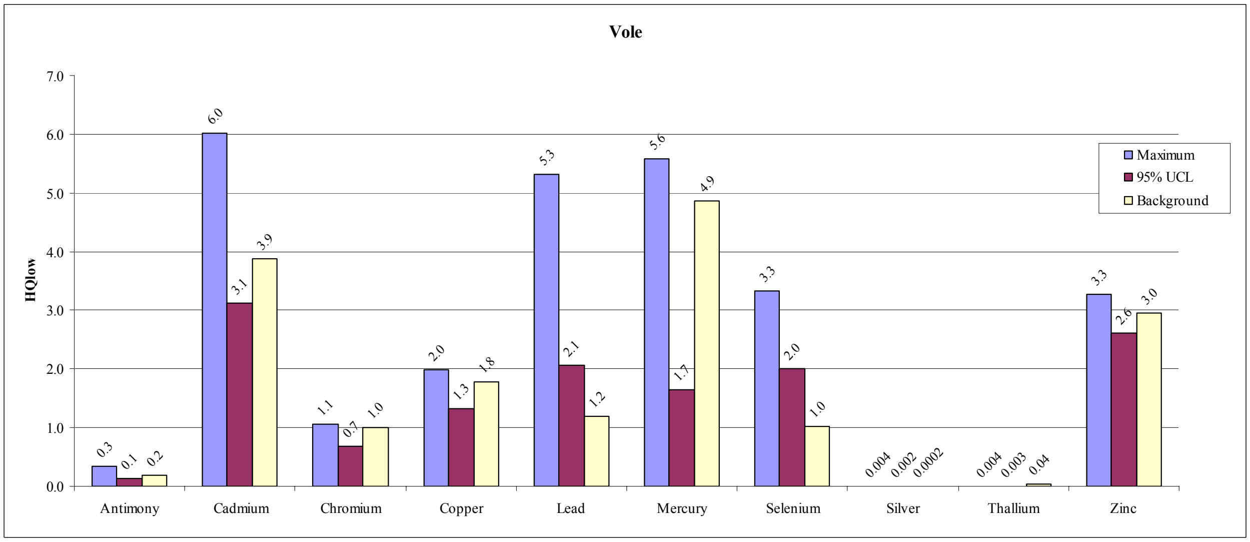

Figure 10. Graphical Comparisons of HQs_{low} for the California Vole

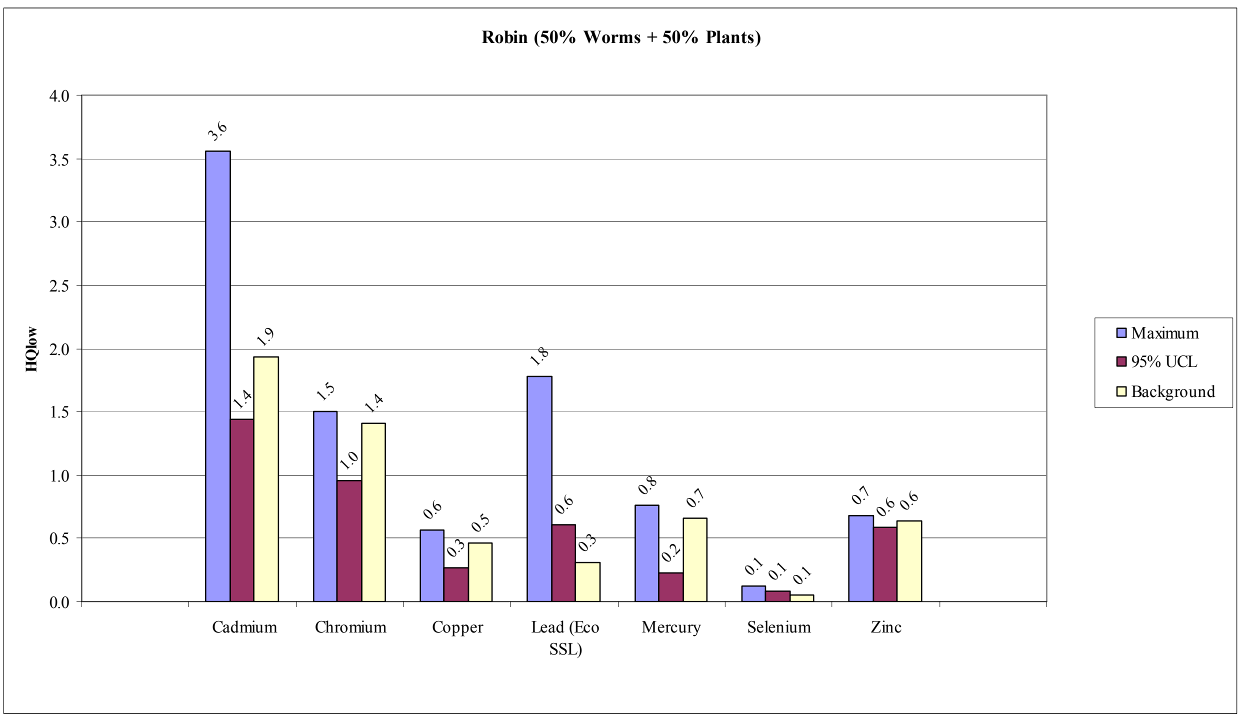

Figure 11. Graphical Comparisons of HQs_{low} for the Robin (omnivorous diet)

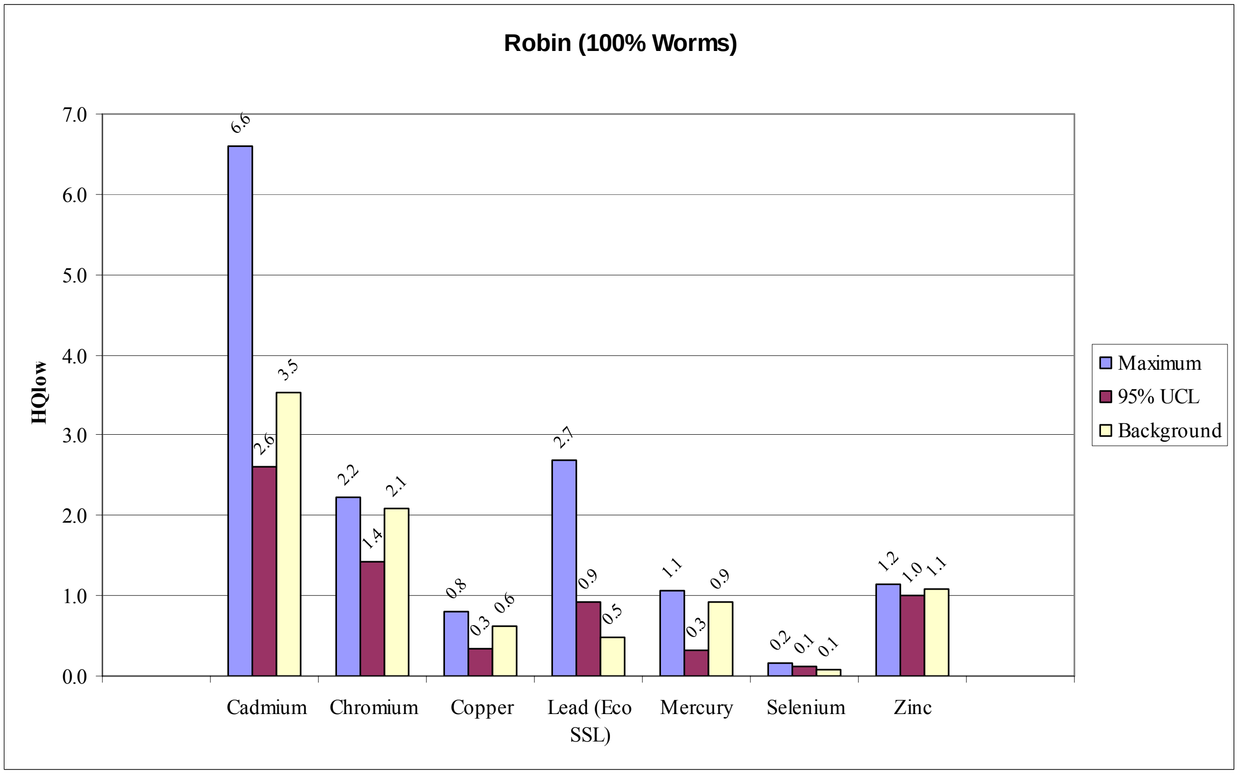

Figure 12. Graphical Comparisons of HQs$_{low}$ for the Robin (invertivorous diet)

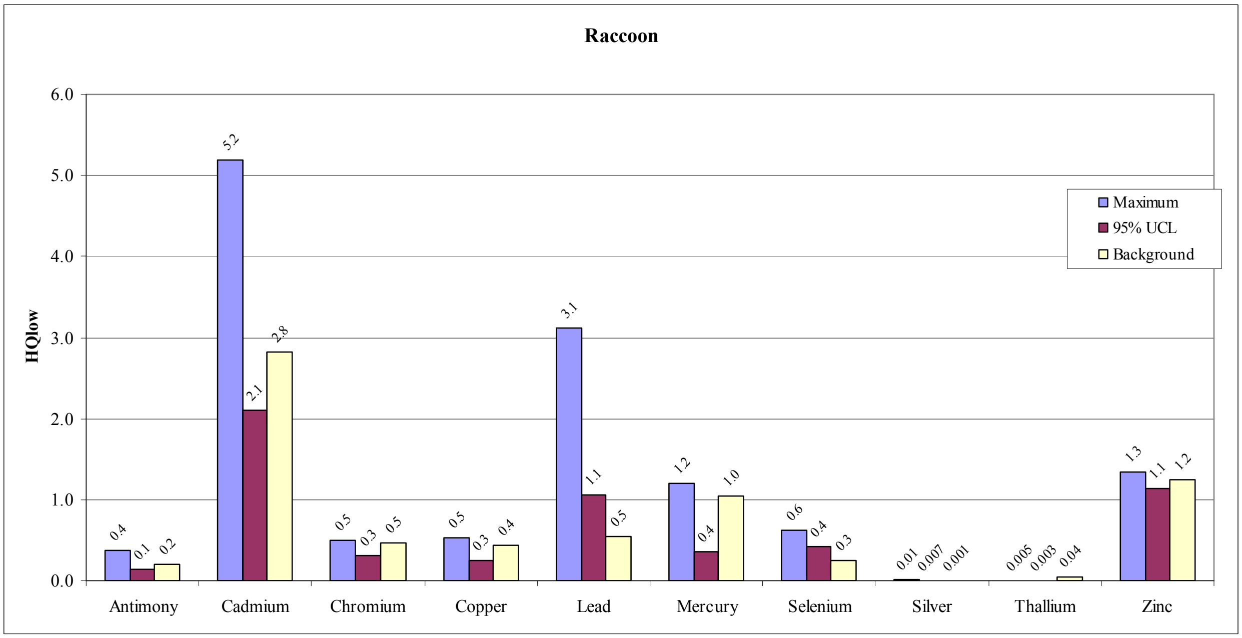

Figure 13. Graphical Comparisons of HQs$_{low}$ for the Raccoon

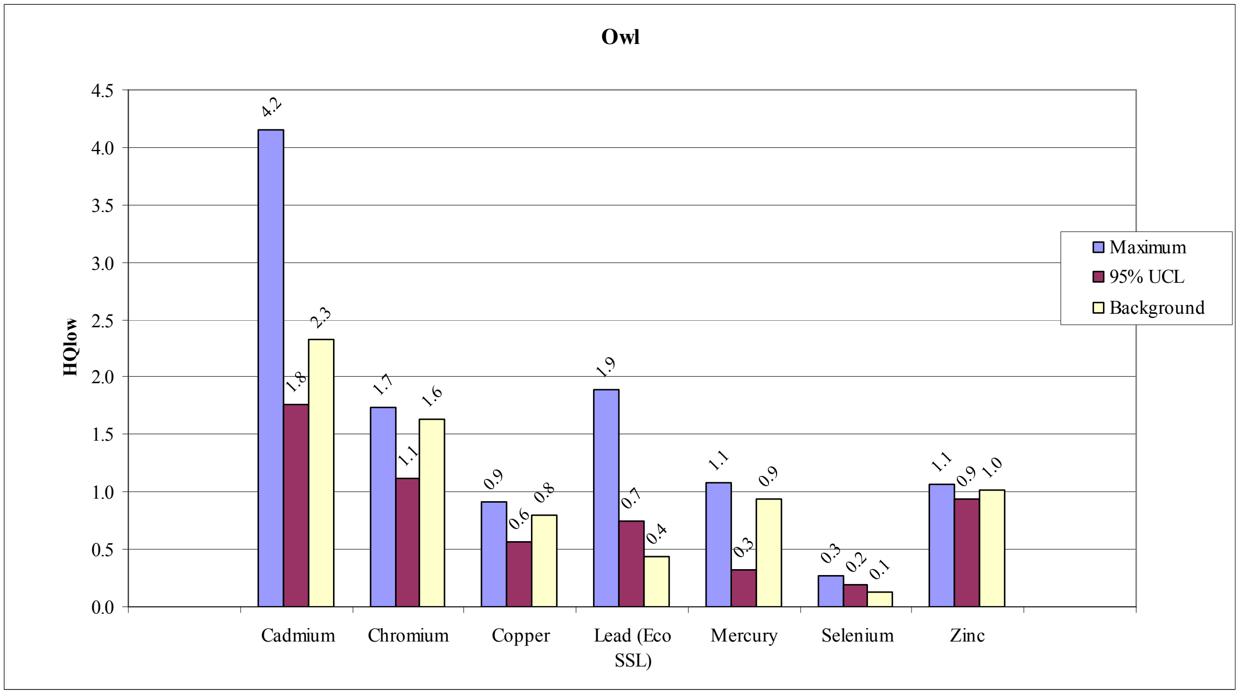

Figure 14. Graphical Comparisons of HQs_{low} for the Owl

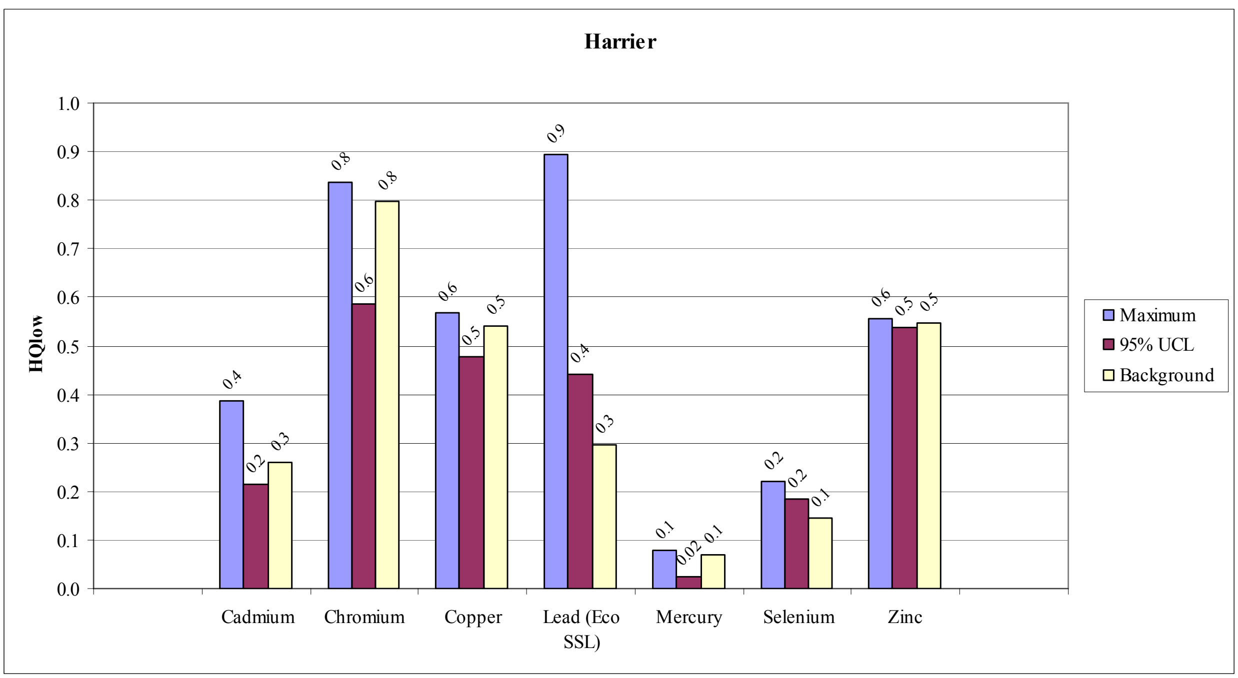

Figure 15. Graphical Comparisons of HQs_{low} for the Harrier

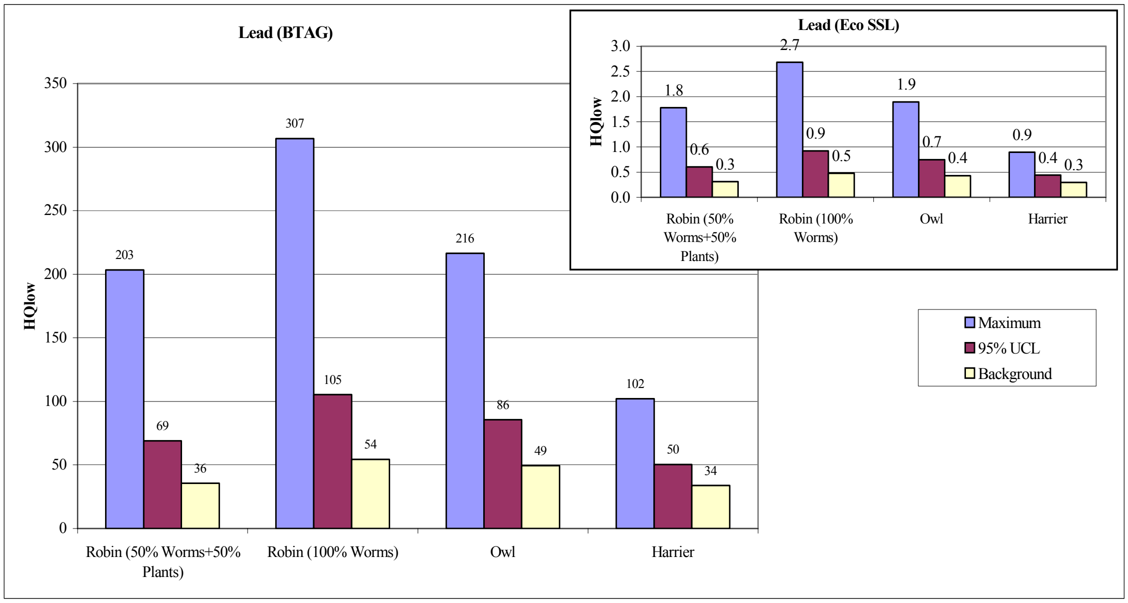

Figure 16. Graphical Comparisons of HQs$_{low}$ for Lead (BTAG) by ROC

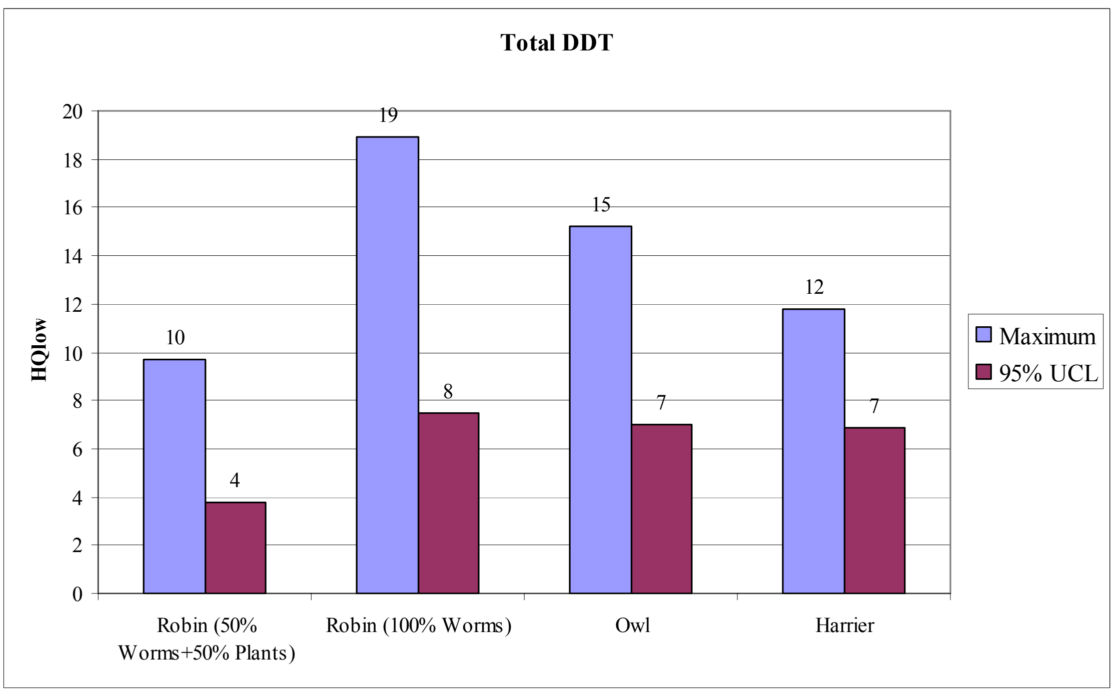

Figure 17. Graphical Comparisons of HQs$_{low}$ for Total DDT (sum of 4,4′-DDD, DDE, and DDT)

Graphical comparisons were not produced for 2,6-DNT and HMX because the maximum and 95% UCL soil concentrations yielded little differences between the HQs_{low}. For 2,6-DNT, the HQs_{low} for the maximum and 95% UCL soil concentrations were 1.1 and 1.0. For HMX, the HQ_{low} in both dose assessments was determined to be 2.2 (the maximum soil concentration was used for both because the 95% UCL soil concentration was greater than the maximum concentration). As discussed in the uncertainty section (Section 6.3), risks for both these compounds are likely to be overestimated given the quality of the analytical data that indicates a presumptive identification of these compounds. Therefore, these two compounds are not considered to be of ecological concern at the Ballfields Parcels.

In addition to the graphical risk comparisons, concentration distribution maps for lead, selenium, and Total DDT are provided on Figures 18 through 20 in order to present the spatial variability of the COPECs in relation to site-wide estimates of risk. Recall that lead and selenium were the only two metals with low TRV HQs above 1.0 and greater than background HQs_{low} and the low TRV HQ for Total DDT was above 1.0. Therefore, concentration distribution maps are only presented for these three COPECs where the association with potential risk is not as clear as it is for the other COPECs. For lead in soil (Figure 18), the majority of concentrations detected in surface soil are below the background concentration of 30.7 mg/kg. Lead concentrations above the 95% UCL soil concentration were detected only in four samples, thus exposure to the majority of the lead in soil would most likely result in risk consistent with background risk and, depending on which low TRV is used (BTAG vs Eco-SSL), an HQ_{low} less than 1.0 (Figure 16).

Concentrations of selenium in soil are fairly consistent across the site (Figure 19) and do not indicate any potential hotspot areas. Concentrations detected are qualified as estimated, indicating that the values are less than the MRL, but above the MDL. Reporting limits for selenium nondetect results in the background data (Table E-1 in Appendix E) vary from 0.34 to 0.88 mg/kg, with two detected results reported as 0.34 mg/kg and 0.37 mg/kg, which are similar to the concentrations detected at the Ballfields Parcels. Based on the low levels detected at the Ballfields Parcels in conjunction with the fairly representative nature of the distribution in soil, the presence of selenium is most likely naturally occurring and is not anticipated to be associated with unacceptable risk.

Concentrations of Total DDT in soil are shown on Figure 20. Concentrations of four samples are higher than the 95% UCL soil concentration of 0.12 mg/kg and are dispersed across the site. Concentrations of the other 11 samples are anywhere from one to two orders of magnitude less than the 95% UCL soil concentration. The low TRV HQs based on the 95% UCL soil concentration range from 4 to 8, depending on the ROC (Figure 17). Because the majority of Total DDT concentrations are much less than the 95% UCL soil concentration, the estimated risk for the ROCs at the site are more likely less than the conservatively estimated HQs_{low} between 4 and 8. As such, exposure to Total DDT at the Ballfields Parcels is not likely to be associated with unacceptable risk.

Potential risks to plants were evaluated by comparing maximum concentrations detected to available conservative screening benchmarks. Total DDT, cobalt, lead, mercury, silver, and zinc exceeded relevant plant screening benchmarks primarily in the former ordnance magazine areas and Revetments 3 and 4. However, observations by various investigators of the existing grassland, including the PA/SI sampling crew, suggest that the cover is complete, and there are not obvious indications of stressed vegetation (IT and CH2M Hill, 2001). As such, chemicals remaining in surface soil at the Ballfields Parcels are not associated with a significant threat to the environment, although adverse effects to plants or other organisms also can result in reduced success of more sensitive species and selection of resistant species which are not readily identifiable effects.

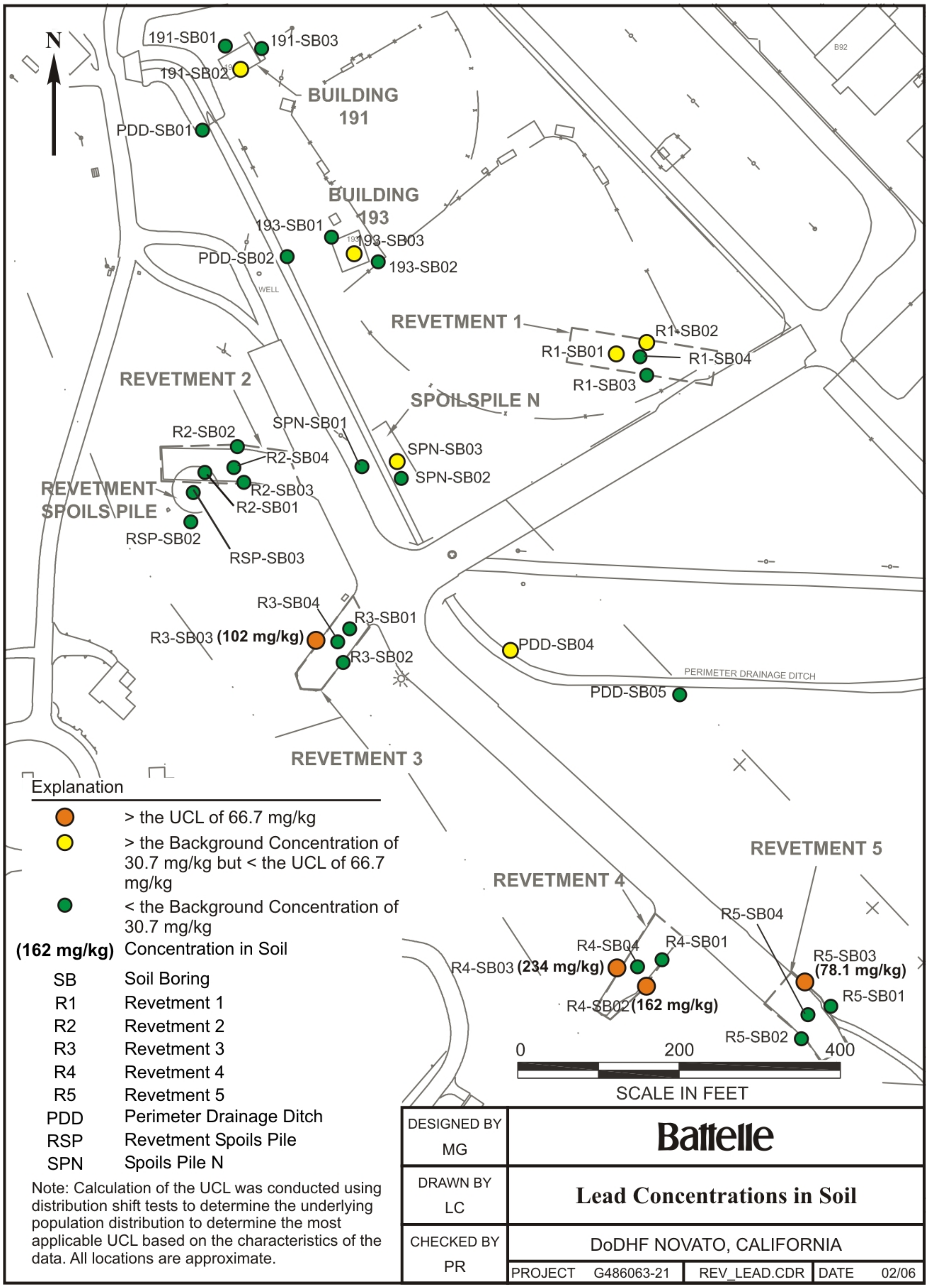

Figure 18. Concentration Distribution of Lead in Soil

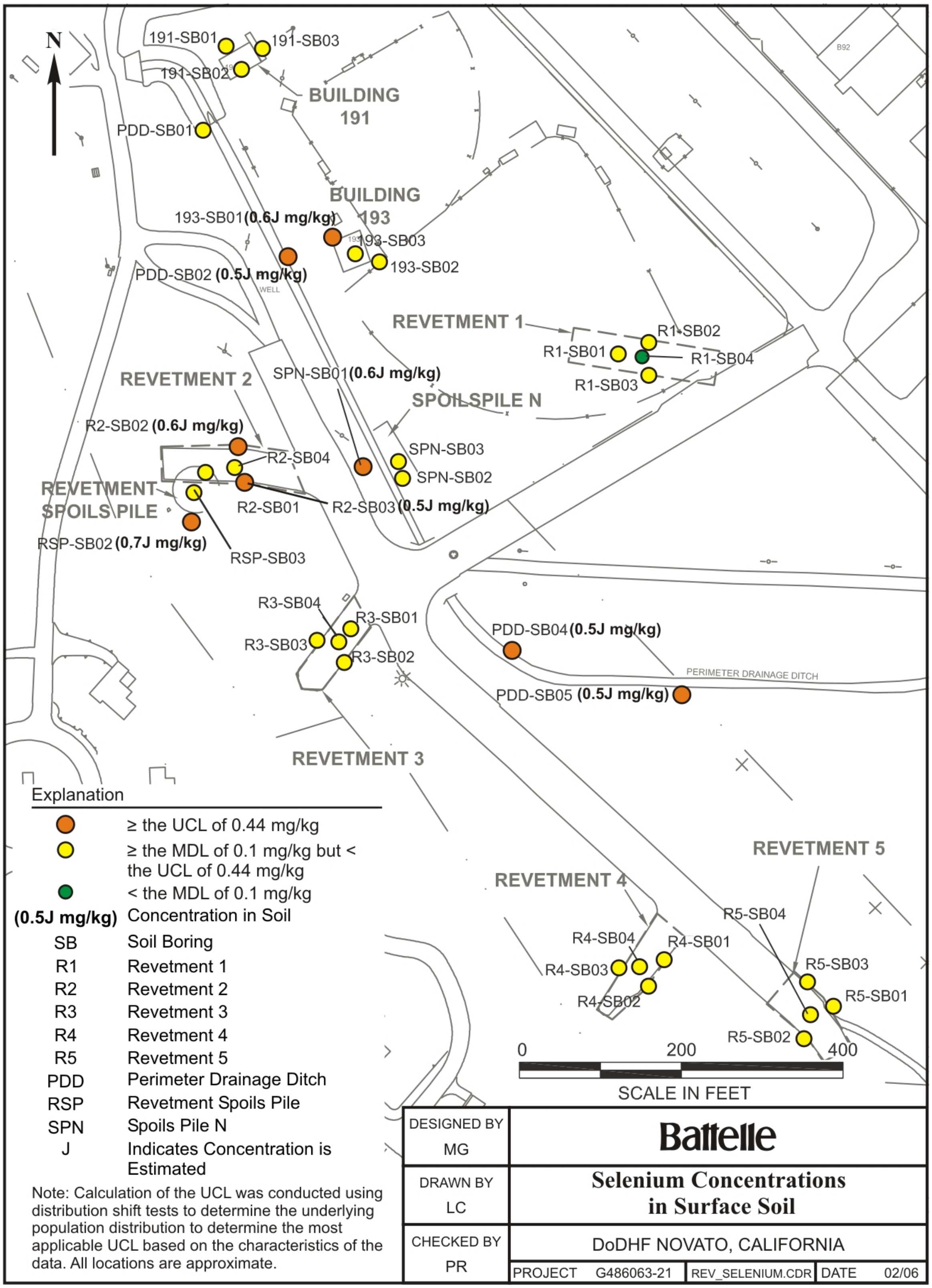

Figure 19. Concentration Distribution of Selenium in Soil

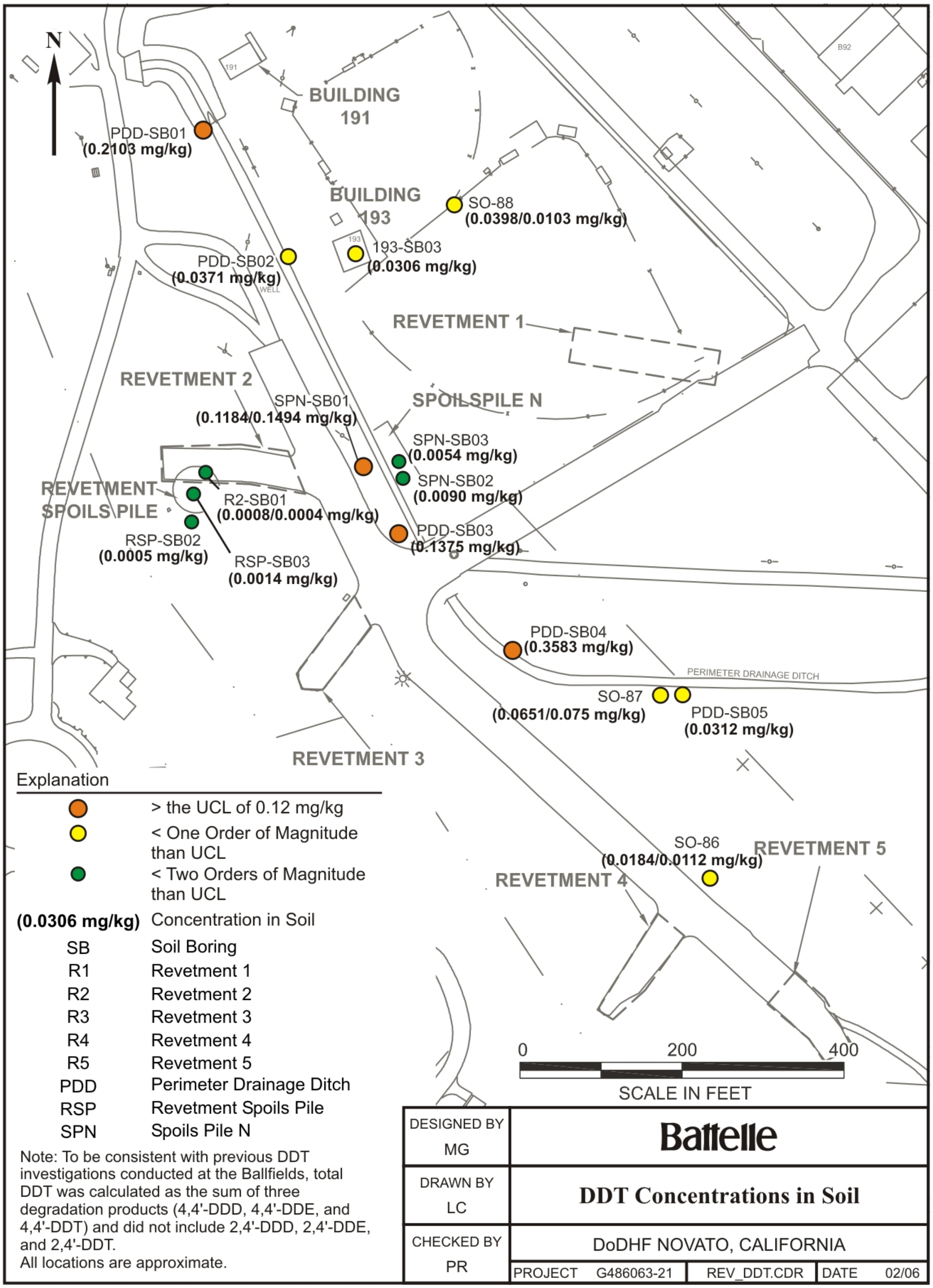

Figure 20. Concentration Distribution of Total DDT in Soil

7.2 Recommendations

Based on the results of the PA/SI and the low-magnitude risk presented to human health and ecological receptors, no further action is recommended for the Ballfields Parcels and it is recommended that the Ballfields Parcels be transferred as is to the CCC for seasonal wetlands reuse.

No Further Action for Soil

No further action for soil is recommended for the Ballfields Parcels based on the results of the human health screening-level risk assessment and ecological assessment. As a conservative measure to assist in making risk-management decisions for the Ballfields Parcels, a hypothetical residential scenario, rather than a more applicable site recreational visitor scenario, was used to evaluate the risks associated with exposure to chemicals in soil. As a result of the conservative nature of the human health screening evaluation, it was determined that exposure to chemicals in soil would not be associated with unacceptable risk to human receptors.

Similarly, the conservative ecological assessment that was conducted for the site resulted in dose estimates all well below known effects levels based on high TRVs and in the majority of cases, determined that risks associated with metals were comparable to background risks. As discussed in the uncertainty section (Section 6.3), low TRVs derived by the BTAG, U.S. EPA Eco-SSL, ORNL, and USACHPPM process represent a no effect level, whereas the high TRVs represent the mid-range of effects levels found in the literature. There is a critical point on the dose-response curve at which effects will first be seen, but that dose is not known. The difference between the low and high TRVs is typically an order of magnitude, and HQs between 1.0 and 10 give an indication of how close the dose may be to the no effect or low effects levels represented by the TRVs. When the difference between the low and high TRV for a COPEC is very great, there is a high degree of uncertainty regarding where effects may first be seen. The difference between the low and high TRVs is greater than two orders of magnitude for some COPECs, such as avian TRVs for Total DDT and lead. A large difference in the high and low TRV for a COPEC increases the uncertainty of risk conclusions based on the magnitude of the low benchmark HQ because it is unknown whether the dose estimated is approaching where first-effects may be found. Given that low TRVs are generally considered to represent no-effect or "safe" levels of exposure below which no effects are expected, and high TRVs are generally considered to represent effect thresholds above which effects may be expected, the magnitude of low TRV HQs and the level of protection indicated by high TRV HQs do not necessarily indicate unacceptable risk for the COPECs in soil. As such, no further action is recommended for soil.

No Further Action for Groundwater

No further action for groundwater is recommended for the Ballfields Parcels based on the results of the human health screening-level risk assessment. As a conservative measure to assist in making risk-management decisions for the Ballfields Parcels, a hypothetical residential scenario, rather than a more applicable site recreational visitor, was used to evaluate the risks associated with exposure to chemicals in groundwater. Under the hypothetical residential exposure scenario, exposure to chemicals in groundwater is conservatively based on the assumption that groundwater beneath the site is used for potable purposes, even though this groundwater is not appropriate for domestic use due to its high TDS, very low recharge rate, decreasing saturated aquifer thickness, and the lack of an adequate confining layer for sanitary well seals. In fact, potable water is currently supplied to the Ballfields Parcels and surrounding area by the City of Novato (IT and CH2M Hill, 2001). Therefore, the groundwater ingestion pathway is not, and likely will not be, complete for an actual residential receptor, or for the more applicable site recreational visitor. The groundwater to indoor air exposure pathway also was evaluated for a hypothetical resident. Risk/hazard results for this pathway were not associated with unacceptable risk to human receptors. Therefore, no further action is recommended for groundwater because exposure to chemicals in groundwater is not a complete exposure pathway for the hypothetical resident or more applicable site recreational visitor.

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